Offspring of the Aurochs: A comparison of a reference collection of Dexter cattle skeletons with archaeological and historical data

GIDNEY, LOUISA,JANE

Contents

Contents 1

List of Tables 7

List of Figures 10

List of Plates 15

List of Abbreviations 21

Declaration 22

Statement of Copyright 22

Acknowledgements 23

Dedication 24

CHAPTER 1 Introduction 25

1.1 Aims and objectives 27

1.2 Major sources of data 28

i. Artistic and historical evidence 28

ii. The Reference Collection of Dexter Skeletons 28

iii. The archaeological sample 31

1.3 Format of thesis 32

CHAPTER 2 The Aurochs and the Domestic Bull 34

2.1 The Legacy of the Aurochs 34

`i. Diminution from the Aurochs to the Dexter 34

ii. Bergmann's Rule 36

iii. The Trophy Head 38

iv. The Ungulate Paradox 40

v. The Rut or Breeding Season 41

2.2 The Domestic Bull 42

2.3 Historical Information 43

i. Sire selection 43

ii. Management of breeding 45

iii. Husbandry 49

iv. Eating quality of bull beef 51

v. Artistic Representations 52

2.3 Data from the Modern Zanfara Dexter Herd 53
2.4 The Dexter Reference Skeletons 56
i. Skeletal ageing 57
ii. Osteology, Pathology and the Stock Bull 57
iii. Skull and Mandibles 59
iv. Ribs and Vertebrae 62
v. Forelimb 65
vi. Hindlimb 67
vii. Phalanges 68
viii. Measurements 70
2.5 Archaeological and Recent Case Studies 71
Case Study 1: Hawick aurochs and Heck cattle 71
Case Study 2: Chillingham Bulls 73
Case Study 3: Comet 76
Case Study 5: The Julius Kühn Museum reference collection, Halle, Germany 79
Case Study 6: Morphology of acetabula from adult bulls 79
2.6 Discussion 80

CHAPTER 3 The Calf (and other young stock: stirks, stots and heifers) 83
3.1 Historical and Literary Information 85
i. Slaughter of the First-Born 86
ii. Weaning from Suckling 87
iii. Calf Slaughter and Vellum 88
iv. Cheesemaking and Rennet 90
v. Seasonality of Calf-Rearing 91
vi. Selection of Traits in Calves to Rear 92
vii. Artistic Representations 93
3. 2 Data from Modern Herds and the Dexter and Jersey Reference Skeletons 94
i. Birth Weights of Dexter Calves 943
ii. Age Estimation of Foetal and Perinatal Calf Bones 97
iii. Chondrodysplasia in the Dexter 98

3.3 The Dexter and Jersey Reference Skeletons 101
i. Stillborn calves 102
ii. Sucking calves 102
iii. Weaned Dexter stirks 103
iv. Jersey grass-fed veal calves 104
v. The Beef Dexters and Jersey Crosses, up to 30 months old 106
vi.Three year old Dexter 113
3.4: Archaeological and Recent Case Studies 114
Case Study one: Ulkestrup Lyng, Neolithic Europe and Grimes Graves 118
Case Study two: Welsh Row, Nantwich 119
Case Study three: Lindisfarne 120
Case Study four: Emden, Germany 121
Case Study five: Monkseaton Chapel Lane 123
Case Study six: Durham Cathedral Precinct 124
3.5 Discussion 127

CHAPTER 4 The Cow: Dairy 130
4.1 Historical Information 130
i. Hendre and Hafod, Shielings and Vaccaries 132
ii. The Breeding Season 135
iii. Everybody's Daughter 136
iv. Artistic Representations 140
4.2 Data from Modern Herds 143
i. Milk Records and Milk Quality 143
ii. Practicalities of Milking 148
iii. Lameness in Dairy Cows 149
iv. Dwarf Dairy Cows 149
4.3 The Dexter Dairy Cow Reference Skeletons 151
i. Skeletal Ageing 156
ii. Osteology, Pathology and the Dairy Cow 157
iii. Skull and Mandibles 157
iv. Ribs and Vertebrae 158

v. Forelimb 159
vi. Hindlimb 159
vii. Phalanges 160
viii. Measurements 160
ix. Discussion 161
4.4 Archaeological Evidence and Case Studies 162
Case Study 1: Neolithic slaughter patterns 165
Case study 2: Possible evidence for dwarf cows 166
Case Study 3: Possible vaccary cows at Green Shiel, Lindisfarne 166
4.5 Discussion 168

CHAPTER 5 The Cow: Beef 172
5.1 Historical Information 173
i. Natural Mortality and Casualty Slaughter 174
ii. The Eating Quality of Cow Beef 175
iii. Artistic Representations 179
iv. Cow Sports 181
5.2 Data from Modern Herds 182
i. Population dynamics of the herd, feeding and housing over winter 182
5.3 The Dexter Suckler Cow Reference Skeletons 186
i. Life Histories of the Dexter Suckler Cows 187
ii. Skeletal Ageing 190
iii. Osteology, Pathology and the Suckler Cow 193
iv. Skull and Mandibles 193
v. Ribs and Vertebrae 195
vi. Forelimb 197
vii. Hindlimb 198
viii. Phalanges 201
ix. Measurements 202
x. Discussion 203
5.4 Archaeological Evidence and Case Studies 206
Case Study 1: Grimes Graves 206

Case Study 2: Lincoln 207
Case Study 3: Flixborough 209
Case Study 4: Ripon Market Place 210
Case Study 5. St Peter's Lane, Leicester 211
5.5 Discussion 212

CHAPTER 6 The Ox 215
6.1 Historical and Literary Information 216
i. Up Corn, Down Horn 217
ii. Status of oxen and ploughmen 218
iii. Age of castration and life span of oxen 219
iv. The Fat Ox 221
v. Eating Quality of Ox Beef 222
vi. Roast Ox 225
vii. Artistic Representations 226
viii. Ox Sports and the Exhibition Ox 228
6.2 Data from Modern Herds 229
i. Training of oxen 229
6.3 The Dexter Ox Reference Skeleton 233
i. Dexter X Jersey Steer 233
ii. Skeletal Ageing 234
iii. Osteology and Pathology 235
iv. Skull and Mandibles 235
v. Ribs and Vertebrae 235
vi. Forelimb 235
vii. Hindlimb 236
viii. Phalanges 236
ix. Measurements 237
x. Discussion 238
6.4 Archaeological Evidence and Case Studies 238
Case Study 1: Example of a "Commoditisation" Interpretation of Archaeological Data 239
Case Study 2: Shapwick 240
Case Study 3: Dorchester 246

Case Study 4: St Giles by Brompton Bridge 247
Case Studies 5 and 6: Masham and Alnwick 248
6.5 Discussion 250

CHAPTER 7 The Herd 253
7.1 The Dexter Reference Collection 253
7.2 Archaeological Comparanda 254
i. Metrical Data 254
ii. Dwarf Cattle 259
iii. Dairy Conformation 260
iv. Size Variation 260
v. Cattle Sports 261
vi. Hunting 261
vii. Calf Slaughter and Milking 262
viii. Pathology 263
ix.Identification of Oxen 263
x. Eating Quality of Meat 264
xi. Women and Cattle 264

CHAPTER 8 Conclusions 266

APPPENDICES 269
Appendix 1: 1 Review of Historical Sources Cited 269
Appendix 2: 1 Bull Sports 275
Appendix 3: 1. Aseasonal Breeding and Calf Survival 282
Appendix 3: 2. Archaeological Ageing Schemes 287
Appendix 4: 1 Milk and calving records for Vycanny cows in reference collection 288
Appendix 5: 1. Zanfara Cull Cows 289
Appendix 6: 1. List of oxen in Boldon Book requisitioned for carting the Bishop of Durham's wine. 291

REFERENCES 292

List of Tables

Table 2:1 Dexter Bulls: Calves sired 330-31

Table 2:2 Scrotal Circumference Data 332-33
Table 2:3 Dexter Bulls: Mandible Wear Stages (after Grant 1982) 334
Table 2:4 Distribution of Osteochondrosis Depressions in Dexter Bulls 335
Table 2:5a. Greatest Length Measurements (mm) 336
Table 2:5b. Estimated Withers Heights from above measurements, using factors of Matolcsi (Driesch & Boessneck 1974, 336) 336
Table 2:5c. Estimated Withers Heights from metapodial measurements, using average of factors for cows and steers given by Boessneck (B), Zalkin (Z), Fock (F) and Matolcsi (M) (Driesch & Boessneck 1974, 336) 336
Table 2:5d. Estimated Withers Heights from metapodial measurements, using factors for entire males (Driesch & Boessneck 1974, 338) 336

Table 3:1 Values of Cattle in Welsh Law (after Wade-Evans 1909, 217) 337
Table 3: 2 Summary of Dexter Calf Weights 338
Table 3: 3 Summary of Knotting herd calf weights 338
Table 3: 4 Knotting herd: calf birth weights by month 338
Table 3: 5 Summary of Harron herd calf weights 339
Table 3: 6 Mean lengths of foetal bones 338
Table 3: 7 Lengths of calf bones: stillborn Dexters and archaeological finds from Lindisfarne. 339
Table 3: 8 Newborn Dexter calf skeletons 339
Table 3: 9 Sucking calves reference skeletons 340
Table 3: 10 Slaughter profile of Jersey calves 340
Table 3: 11 Young male Dexters for whom some bones are extant 341
Table 3: 12 Epiphysial fusion Dexter cull cohort 11-30 months 342
Table 3: 13 Epiphysial fusion Jersey cross cull cohort 11-30 months 342
Table 3:14 Distribution of osteochondrosis depressions in Dexter male cull cohort 6-30 months old 343
Table 3: 15 Distribution of osteochondrosis depressions in Jersey X

male cull cohort 11-30 months 344

Table 3: 16 . Epiphysial fusion in feet of Dexter steers 345
Table 3:17 Distribution of osteochondrosis depressions on feet of Dexter steers 345
Table 3: 18 Karst and Aurelian, distribution of osteochondrosis depressions 346
Table 3: 19 Karst and Aurelian epiphysial fusion 347
Table 3: 20 Mandible Wear Stages Young Dexters 348
Table 3: 21 Dusty epiphysial fusion 349
Table 3: 22 Romano-British calf bones from Nantwich and Dexter calf 350
Table 3: 23 Emden: foetal calves 350
Table 3: 24 Monkseaton Chapel Lane foetal calf bone lengths 350
Table 3: 25 Occurrence of veal in Thacker's cookery book 351
Table 3: 26 Thacker's Bills of Fare for the Residency of the Dean 351
Table 3: 27 Durham, Dexter and Jersey calf bone lengths 352
Table 3: 28 Durham and Dexter TWS (after Grant 1982) 352

Table 4:1 Vycanny Conqueror's Glenisla: surviving milk records 353
Table 4: 2 Mandible Wear Stages for the Vycanny cows 354
Table 4: 3a Vycanny cows: Greatest Length Measurements (mm) 355
Table 4: 3b Vycanny cows: Estimated Withers Heights (in m) from above measurements, using factors of Matolcsi 354
Table 4: 3c Estimated Withers Heights of Vycanny cows from metacarpal measurements, using average of factors for cows and steers given by Boessneck (B), Zalkin (Z), Fock (F) and Matolcsi (M) 355
Table 4: 3d Estimated Withers Heights of Vycanny cows from metacarpal measurements, using factors for cows 355
Table 4: 4 Green Shiel TWS/MWS 356
Table 4: 5a. Green Shiel: Greatest Lengths (GL in mm) and estimated Withers Heights (WH in m), using factors of Matolcsi 356
Table 4: 5b. Green Shiel: Estimated Withers Heights from metapodial measurements, using average of factors for cows and steers 356

Table 5: 1 MWS for the Dexter suckler cows 357
Table 5:2a. Suckler cows: Greatest Length Measurements (mm) 358
Table 5: 2b. Suckler cows: Estimated Withers Heights (in m) from above measurements, using factors of Matolcsi 358
Table 5: 2c. Suckler cows: Estimated Withers Heights from metacarpal measurements, using average of factors for cows and steers given by Boessneck (B), Zalkin (Z), Fock (F) and Matolcsi (M) 358
Table 5: 2d. Suckler cows: Estimated Withers Heights from metacarpal measurements, using factors for cows 358

Table 6: 1 Stages of epipysial fusion, Hadza and Dusty 359
Table 6: 2 Tooth Wear Stages, Hadza and Dusty 360
Table 6: 3 Shapwick, metapodial measurements and estimated withers heights 360
Table 6: 4 Shapwick epiphysial fusion 361
Table 6: 5 St Giles by Brompton Bridge, cattle tooth wear stages compared with Hadza and Dusty 362
Table 6: 6 St Giles by Brompton Bridge, comparison of epiphysial fusion with the Dexters Hadza and Dusty 362

Table 7: 1 Log Ratio results received in lieu of annotated graph 257

List of Figures

Figure 2:1 Pedigree of Shorthorn bull Comet 363

Figure 2: 2a Dexters and Chillingham, comparison of humerus distal trochlea 363

Figure 2: 2b Dexters and Chillingham, comparison of distal tibia 364

Figure 2: 2c Comparison of humerus distal trochlea between aurochs and Comet with Chillingham and Dexters 364

Figure 3: 1 Seasonality of calving in Heck cattle at Oostvordersplassen 2003 and Chillingham cattle in 1862-1898 and 1953-1984 365

Figure 3: 2 Central Ethiopian Highlands: birth months of calves 365

Figure 3: 3 Zanfara Dexter Herd: birth months of calves 366

Figure 3: 4 Knotting Dexter Herd: birth months of calves 366

Figure 3: 5a. All Bull and Heifer calves, excluding Knotting Herd 367

Figure 3: 5b. Bull and Heifer calves, excluding Knotting Herd 367

Figure 3: 5c. Bull calves, excluding Knotting Herd 368

Figure 3: 5d. Heifer calves, excluding Knotting Herd 368

Figure 3: 5e. Heifer calves, weights in pounds, excluding Knotting Herd 369

Figure 3: 5f. Knotting herd birth weights 369

Figure 3: 5g. Knotting herd birth weights compared to all other herds 370

Figure 3: 5h. All Dexter Birth weights, including Knotting 370

Figure 3: 5i. Knotting Heifer Calves Birth Weights 371

Figure 3: 5j. Knotting Bull Calves Birth Weights 371

Figure 3: 5k. Knotting Herd Full Term Live Births: Bull and Heifer Calves 372

Figure 3: 5l. Knotting Herd Comparison of Live and Stillborn Calf Birth Weights 372

Figure 3: 5m. Knotting Herd Comparison of Full term and Premature Live and Stillborn Calf Birth Weights 373

Figure 3: 5n. Harron Herd All Birth Weights 373

Figure 3: 5o. Harron Herd Birth Weights for Bull and Heifer Calves 374

Figure 3: 6 Age distribution of Dexter beef cull cohort 374

Figure 3: 7 Age distribution of beefed male Dexters with some extant bones 375
Figure 3: 8 Male beef Dexters and Jersey crosses with some extant bones 375
Figure 3: 9a Astragalus measurements of Dexter young males 376
Figure 3: 9b Astragalus measurements, young Dexter males and adult bulls 376
Figure 3: 9c Astragalus measurements Dexter males entire and castrate 377
Figure 3: 9d Astragalus measurements young Dexter and Jersey cross males 377
Figure 3: 9e Astragalus measurements including heifer Dusty 378
Figure 3: 10a Humerus distal trochlea measurements, Dexter males entire and castrate 378
Figure 3: 10b Humerus distal trochlea measurements, non-short and short males 379
Figure 3: 10c Humerus distal trochlea measurements, young Dexter and Jersey X males 379
Figure 3: 10d Humerus distal troclea measurements, heifer Dusty compared with Dexter males 380
Figure 3: 11a Green Shiel calf metatarsals 380
Figure 3: 11b Green Shiel calf metatarsals with comparanda 381
Figure 3: 12a Emden and Dexter calf scapulae 381
Figure 3: 12b Emden and Dexter calf humeri 382
Figure 3: 12c Emden and Dexter calf radii 382
Figure 3: 12d Emden and Dexter calf femora 383
Figure 3: 12e Emden and Dexter calf tibiae 383
Figure 3: 13 Emden cattle withers heights 384

Figure 4: 1 Figure 4: 1 Lactation Curve 385
Figure 4: 2 Vycanny Dexter Herd: Distribution of Days in Milk 385
Figure 4: 3 Heights of normal and dwarf Jersey cows in one American herd 386
Figure 4: 4 Vycanny Herd, Annual recorded lactations 386
Figure 4: 5a Vycanny cows, humerus distal trochlea measurements 387
Figure 4: 5b Vycanny cows and two bulls, humerus distal

trochlea measurements 387
Figure 4: 5c Vycanny cows, distal tibia measurements 388
Figure 4: 5d Vycanny cows and two bulls, distal tibia 388
Figure 4: 6 Estimated cattle withers heights for Vindolanda and South Shields Roman forts 389
Figure 4: 7 Green Shiel and Vycanny cows, distal humerus 389
Figure 4: 8 Green Shiel and Vycanny cows, distal tibia 390

Figure 5: 1 Mortality of cows in reference collection and Zanfara cows not in reference collection 391
Figure 5: 2 Calendar age at death: Halle collection, Dexter cows and adult bulls 391
Figure 5: 3 MWS for Halle collection, Dexter cows and adult bulls 392
Figure 5: 4a Suckler cows, humerus distal trochlea measurements 392
Figure 5: 4b Comparison of all cows and adult bulls, humerus distal trochlea measurements 393
Figure 5: 5a Suckler cows and two bulls, distal tibia measurements 393
Figure 5: 5b Comparison of all cows and adult bulls, distal tibia measurements 394
Figure 5: 6a Suckler cows, astragalus measurements 394
Figure 5: 6b Comparison of all cows and adult bulls, astragalus measurements 395
Figure 5: 6c Comparison of all cows, adult and immature males, astragalus measurements 395
Figure 5: 7 Comparsion of withers heights of short and non-short Dexter and Jersey cows 396
Figure 5: 8a Grimes Graves and Dexters, estimated withers heights 396
Figure 5: 8b Grimes Graves and Dexters, Distal Breadth metacarpals 397
Figure 5: 8c Grimes Graves and Dexters, astragali measurements 397
Figure 5: 9a C4th Lincoln and Dexters, estimated withers heights 398
Figure 5: 9b C4th Lincoln and Dexters, Distal Breadth metacarpals 398
Figure 5: 9c C4th Lincoln and Dexters, astragali measurements 399
Figure 5: 10 Ripon and Dexters, Distal Breadth metacarpals 399
Figure 5: 11a Leicester and all Dexters, astragali 400

Figure 5: 11b Leicester and Dexter cows, astragali 400

Figure 6: 1 Distal humerus trochlea measurements: Hadza, Dusty and all Dexter males 401
Figure 6: 2 Astragalus, comparison of GL and DB measurements: Hadza, Dusty, Dexter and Jersey X males 401
Figure 6: 3 Astragalus, comparison of GL and DB measurements: Hadza, all Dexter males and females 402
Figure 6: 4 Distal tibia DB and DD measurements: Hadza and adult Dexters 402
Figure 6: 5 Withers Heights estimated from metacarpal GL: Hadza and adult Dexters 403
Figure 6: 6 Shapwick Burial Pit: MWS 403
Figure 6: 7 Dorchester: withers heights estimated from metacarpal GL 404
Figure 6: 8 Comparison of Dorchester and Alnwick estimated withers heights with Hadza, Brough St Giles and Comet 404
Figure 6: 9 Comparison of Dorchester and Masham proximal metacarpals PB with Hadza and Comet 405
Figure 6: 10 Comparison of Dorchester and Masham distal metacarpals DB with Hadza and Comet 405

Figure 7: 1. Comparison of distal humerus breadth in Dexters with Hambledon Hill range 406
Figure 7: 2. Comparison of distal humerus breadth in male and female Dexters with Hambledon Hill range 406
Figure 7: 3. Comparison of Hambledon Hill range with Dexters moved up to same size range 407
Figure 7: 4. Comparison of Hambledon Hill range with male and female Dexters moved up to same size range 407
Figure 7: 5a. Scatterplot comparison of Hambledon Hill and Dexter humerus distal trochlea dimensions. The line approximates to Legge's proposed separation between Neolithic domestic cattle and aurochs. 408
Figure 7: 5b Scatterplot comparison of Hambledon Hill and Dexter humerus distal trochlea dimensions with Hawick aurochs bull and Shorthorn bull Comet. 408

Figure 7: 5c Scatterplot comparison of Neolithic Rudston Wold and Hambledon Hill with Mesolithic aurochs. (from Rowley-Conwy and Owen 2011) 409
Figure 7: 6. The whole sample of Dexter humerus distal trochlea measurements. Graph submitted to specialists to suggest division into male, female and castrate ranges. 410
Figures 7: 7a-j Responses received to the request submitted with Figure 7: 6
Figure 7: 7a 410
Figure 7: 7b 411
Figure 7: 7c 411
Figure 7: 7d 412
Figure 7: 7e 412
Figure 7: 7f 413
Figure 7: 7g 413
Figure 7: 7h 414
Figure 7: 7i 414
Figure 7: 7j 415
Figure 7: 8a. Key to sex/age distributions in Figure 7: 6 416
Figure 7: 8b. Key to Short (S) and Non-Short (NS) male and female Dexters in Figure 7: 6 416
Figure 7: 9. Comparsion of Dexter distal humerus measurements with Bronze Age Grimes Graves 417

List of Plates

Plate 1: 1 Detail of *Farm Girl at her Toilet* by Lepoittevin. 418

Plate 2: 1. Dexter bull left, and cow right, showing the lack of pronounced sexual dimorphism in height in the non-short Dexter. 419

Plate 2: 2a. Countrywoman confronting bull, by Bewick c. 1790 419

Plate 2: 2b Man running from bull, by Bewick c. 1790 420

Plate 2: 3a-b. Yoked bulls 420-21

Plate 2: 4 Bull fight in Thailand 421

Plate 2: 5 Reproduction of Roman oil lamp with acrobat pole vaulting over bull 422

Plate 2: 6 Juglans Nigra competing at the East of England show, 1993 422

Plate 2: 7 Alcalde, aged 16, premier sire of bulls for the Spanish bullring 423

Plate 2: 8 Roman amphitheatre at Arles with bull fight in progress 423

Plate 2: 9 Limousin cattle with "Celtic Shorthorn" shaped horns 424

Plate 2:10 Juglans Nigra and Cyclone in harmony 424

Plate 2: 11a-d Dexter bull head rubbing sites: a, Thomas; b, Juglans Nigra, c, Orlando; d, Lawrence 425

Plate 2: 12a Zanfara Orlando showing robust neck 426

Plate 2: 12b Zanfara Thomasina showing gracile neck 426

Plate 2: 13a Sacrum of Juglans Nigra fused to iliac blades of pelvis 427

Plate 2: 13b Sacrum of Cyclone fused to iliac blades of pelvis 427

Plate 2: 14 a-c First phalanges of Cyclone showing the range of exostosis development 428

Plate 2: 15 a-c Cyclone second and third phalanges showing the range of exostosis development 429

Plate 2: 16a Detail of surface modelling on humeri of Juglans Nigra, left, and aurochs, right 430

Plate 2: 16b Scapulae, L-R aurochs, Juglans Nigra, Cyclone and Chillingham, showing the gracile build of the Chillingham 430

Plate 2: 16c Humeri, L-R aurochs, Juglans Nigra, Chillingham, Cyclone 431

Plate 2: 17 Atlas vertebrae, Chillingham, Cyclone, Juglans Nigra 431

Plate 2: 18 Radius and ulna, L-R Cyclone, Juglans Nigra, Chillingham 432
Plate 2: 19 Metacarpals, L-R Cyclone, Juglans Nigra, Chillingham 432
Plate 2: 20 Comet in 1811, aged 7, a year after the Colling's dispersal sale. Detail of painting by Thomas Weaver. 433
Plate 2: 21 Malocclusion on right hand mandibular molar 3 of Comet, indicative of a "hooked" occluding maxillary molar 3 433
Plate 2: 22a-c Left scapula of Comet showing ossification round the joint capsule in response to subluxation: a, medial aspect; b, lateral aspect; c, detail of eburnation in the glenoid fossa; d, detail of ossification round the margins of the joint capsule 434
Plate 2: 23 Comet right humerus, proximal end showing extension and fusion of the lateral and medial tuberosities 435
Plate 2: 24a-f Bull acetabula a, medieval example, Ripon; b, Hawick aurochs; c, Juglans Nigra; d, Cyclone; e, Chillingham 1947; f, Chillingham 1980 436

Plate 3: 1 Bestiary image of red heifer being milked with calf in attendance 437
Plate 3: 2 Bestiary image of gambolling calves 437
Plates 3: 3a-e Dun calves showing winter coats with long guard hairs and woolly undercoat
3: 3a Pyrite 438
3: 3b Pyrite: showing long guard hairs and short, woolly undercoat 438
3: 3c Detail of Pyrite's coat 438
3: 3d Detail of Rebekanda's coat 438
3: 3e Olivine displaying the same double coat 438
Plates 3: 4a-d Four views of bulldog calf born in the Zanfara herd 439
Plates 3: 5a-e Dozey: Pathological changes to femora, calcanea and acetabulae
3: 5a anterior view of femora showing displaced capitula 440
3: 5b posterior view of femora showing displaced capitula 440
3: 5c proximal view of femora 440
3: 5d calcanea 440
3: 5d Pubes, ischia, caudal half of acetabula 440
Plate 3: 6 Radii of Jersey, Edward and short-leg Dexter, Medlar 441
Plate 3: 7a Apicius cervical-thoracic vertebrae, lateral view 442
Plate 3: 7b Apicius cervical-thoracic vertebrae, medial view 442
Plate 3: 8a Apicius sacrum, cranial view 442

Plate 3: 8b Apicius sacrum, dorsal view 442
Plate 3: 9 Nantwich, Dexter and commercial calf humeri 443
Plate 3: 10 Monkseaton Chapel Lane, cow skeleton with calf bones in abdominal region 443
Plate 3: 11 Durham and Tinkerbel metacarpals 444
Plates 3: 12a-c Durham 18th century (brown) and new-born Dexter (white) calf frontal bones
3: 12a dorsal view 445
3: 12b lateral view 445
3: 12c lateral view 445
Plate 3: 13a. Aurelian, bull, showing pronounced horn buds 446
Plate 3: 13b Tittlemouse, heifer, horn buds concealed by hair 446
Plate 3: 13c Aurelian left, Tittlemouse right. In a different pose, horn buds still visible on the bull calf but not the heifer 446

Plate 4: 1 Grinstead Trixie 8th, an example of a mid 20th century dairy conformation Dexter cow 447
Plate 4: 2 Augsburg, Germany: early 16th century wall painting for the month of April, detail depicting a cow mounting another cow in oestrus 447
Plate 4: 3 Shorthorn cow being handmilked while unrestrained, c. 1951-4 448
Plate 4: 4 Early 16th century depiction of unrestrained cow, with no calf, being milked 449
Plate 4: 5a Modern breed with “crumpled horn”: Norwegian Vestlandsk Fjordfe 449
Plate 4: 5b Modern breed with “crumpled horn”: Italian Cinisara 450
Plate 4: 5b Early 20th century Kerry cow with “crumpled horn” 450
Plate 4: 6a Dun Cow sculpture group on Durham Cathedral 451
Plate 4: 6b 19th century sketch of the same Dun Cow sculpture group 451
Plate 4: 7a Parndon Green Finch, aged 29 452
Plate 4: 7b Kirstie in life 452
Plates 4: 7c Kirstie in life 453
Plate 4: 8 Depression in horn core of Vycanny Kirstie 453
Plate 4: 9 Glenteitney caudal articulation VL6 454
Plate 4: 10 Glenteitney cranial articulation sacrum 454
Plate 4: 11 Glenteitney lumbar and sacral vertebrae 454

Plate 4: 12 Glenfinlet lumbar and sacral vertebrae 455
Plate 4: 13 Kirstie Lumbar and sacral vertebrae 455
Plate 4: 14 Keepsake Lumbar and sacral vertebrae 455
Plate 4: 15 Vycanny cow showing raised tail head at the lumbar-sacral boundary. Note also "dairy wedge" outline and the upright "crumpled" horns of the cow on the right. 456
Plate 4: 16 Vycanny Kirstie metatarsals, posterior view 456
Plate 4: 17 Left distal metacarpal from medieval deposits at Tuthill Stairs, Newcastle upon Tyne; right metacarpal of Vycanny cow Glenfinlet 457
Plate 4: 18 Humeri: L & R Vycanny cows, centre Green Shiel 457
Plate 4: 19 Tibiae: L & R Vycanny cows, centre Green Shiel 458
Plate 4: 20 L Green Shiel, R Chillingham bull 458
Plate 4: 21 Dexter cow in 2012, showing beef conformation 459

Plates 5: 1a-d Cow combat at turn out in the Zanfara herd, 2009 460
5: 1a. Laurelanda issuing a challenge
5: 1b. Tiggywinkle (left) establishing her rating as a newly-calved heifer
5: 1c continuing the same interaction
5: 1d Pyrite, right, attempting to dominate Tiggywinkle
Plates 5: 2 Naturally mummified head of Bryn Y Pin Betula 461
5: 2a frontal aspect
5: 2b lateral view
5: 2c showing separation of vertebrae
Plate 5: 3a Godstone Abby, 1989 462
Plate 5: 3b Abby with Chalena's calf, 1989 462
Plate 5: 4 Chalena after calving, 1989 463
Plate 5: 5a Cassie when newly calved in 1992 463
Plate 5: 5b Cassie when newly calved in 1992 464
Plate 5: 6 Meadow Pipit in 1988 465
Plate 5: 7 Chevette in 1993 465
Plate 5: 8 Clover at Ryedale Show 1983 466
Plate 5: 9 Glenalmond in 1983 466
Plate 5: 10a-c Abby, right mandible showing healed trauma 467

5: 10a lateral view
5: 10b medial view
5: 10c ventral view
Plate 5: 11 Cassie, showing perforation in occipital 468
Plate 5: 12 Chevette, showing perforation above left occipital process 468
Plate 5: 13a-b Glenalmond, ribs showing healed fractures 469
Plate 5: 14 Meadow Pipit, foramina on centra of thoracic vertebrae 470
Plate 5: 15a Cassie, foramina on centra of thoracic vertebrae 470
Plates 5: 15b-c Cassie, foramina on centra of lumbar vertebrae 471
Plates 5:15d-e Cassie, arthropathies on lumbar-sacral joint 472
5: 15d caudal aspect of VL6
5: 15e cranial aspect of sacrum
Plate 5: 16a-b Chalena and Meadow Pipit, scapulae 473
5: 16a lateral aspect
5: 16b medial aspect
Plate 5 : 17a Clover, arthropathy on acetabulum 474
Plate 5: 17b-c Clover, arthropathy on articulating femoral head 474
5: 17b anterior aspect
5: 17c detail of femoral head

Plate 6: 1. Pack and riding oxen in the Sudan, 1934. (DUL SAD 705/4/5) 475
Plate 6: 2a Dexter cattle being used to tread cob for walling 475
Plate 6: 2b Detail of Dexter cattle treading cob 476
Plate 6: 3 Bantu and Wellington in training yoke, ploughing at Bede's World 476
Plate 6: 4 One of the Dexter oxen as a weaned stirk 477
Plate 6: 5 Bantu at 11 years old, with a related female, demonstrating the range of phenotype within one genotype 477
Plates 6: 6 a Bantu and Wellington in traditional withers yoke 478
Plate 6: 6b Bantu and Wellington in withers yoke, being led by the author 478
Plate 6: 7 Dexter heifers Jaquinta and Clarissa in training yoke 479
Plate 6: 8a Oswald and Oswin at Bede's World 479
Plates 6: 8b-c Oswald and Oswin at Bede's World 480
Plate 6: 9a The 2013 Darlington roast ox standing in its frame, after removal from the oven, with the Master Butcher in attendance 481

Plate 6: 9b Serving the 2013 Darlington Roast Ox, calor gas-fired oven on trailer in background 481
Plate 6: 10 Exhibition Shorthorn Ox with Dexter heifer, souvenir postcard from 1950's agricultural show in Weardale 482
Plate 6: 11 Hadza and Juglans Nigra in life 482
Plate 6: 12 Relative shoulder heights of Bantu, the author and Clarissa 483
Plate 6: 13 Bantu and Clarissa comparing absolute size difference of heads with comparable horn morphology 483
Plates 6: 14a The Shapwick burial pit during excavation 484
Plates 6: 14b The Shapwick burial pit during excavation, detail 484

List of Abbreviations

A.I.	Artificial Insemination
BSE	Bovine Spongiform Encephalitis
BVD	Bovine Viral Diahorrea
CM	Certificate of Merit
CVM	Complex Vertebral Malformation
DCS	Dexter Cattle Society
DEFRA	Department for Environment, Food and Rural Affairs
IBR	Infectious Bovine Rhinitis
MMB	Milk Marketing Board
MWS	Mandible Wear Score (after Grant 1982)
OCDS	Older Cattle Disposal Scheme
OTM	Over Thirty Months
OTMS	Over Thirty Months Scheme
PD	Pregnancy Diagnosis
RBST	Rare Breeds Survival Trust
RM	Register of Merit
SD	Standard Deviation
TWS	Tooth Wear Score (after Grant 1982)

Declaration

This thesis conforms to the prescribed word length for doctoral degrees.
This thesis is the result of my own work. None of the material presented here has previously been submitted by the author for a degree at Durham University or at any other university. Material from the work of others has been acknowledged and quotations and paraphrases have been indicated.

Statement of Copyright

Acknowledgments

I would like to express my deep gratitude to the Dexter owners who provided the animals for the reference skeletons at below market value: in particular the late Valerie Roberts of the Vycanny herd; John and Pat Garratt of the Butterbox herd, who sourced the foundation heifer for the Zanfara herd and are still providing moral support; the late Moira Arkle of the Bryn Y Pin herd; Bill Quay Community Farm; Mr & Mrs Hadleigh of the Brandex herd. Angela Wray of the Risplith Jersey herd provided all the Jersey and Jersey X calves double-suckled on the Dexters.

Particular thanks are due to the butchers who dealt sympathetically with my requests to turn live cattle into raw skeletons: Mr Brownless, Barnard Castle; staff at Peat's, Barnard Castle; Joe Simpson and staff, Cockfield; Messrs Nattrass, Westgate. A special mention must be made of Paul Stokes for inestimable assistance in carcase preparation (the legendary Kirstieburgers!).

Moral support has been ongoing from former members of the English Heritage Biological Laboratory, James Rackham, Jacqui Huntley and Sue Stallibrass; past and present members of the Archaeological Services Environmental Laboratory, Helen Ranner, Bryan Atkinson, Charlotte O'Brien, Lorne Elliot, Janet Beveridge, Janice Adams, Trix Randerson, Dave Webster, Carrie Drew.

The Department of Archaeology brought the project to fruition by initially supporting a staff candidacy but also continuing to support the thesis after redundancy from the Department. Special thanks are owed to the supervisory team. Chris Gerrard provided the "Roundtuit" motivation to write up. Tina Jakob provided unfailing support during the redundancy process and the final writing stage.

A huge debt of gratitude is owed to the late Denis Coggins, former Antiquities Officer at the Bowes Museum, who taught me far more than I appreciated at the time about field archaeology and livestock husbandry.

Dedication

This thesis is dedicated to the late Denis Coggins and Valerie Roberts, who had faith in the inception of the project though they did not live to see it come to completion. Giants, on whose shoulders I am proud to stand.

Miss Valerie Roberts with the Inter-Breed Champion, Cleveland County Show c. 1994

Chapter 1. Introduction

Cattle bones are the most common faunal remains recovered by hand excavation; a simple truth of the archaeological record which reflects the size and robustness of the bones. Yet despite the ubiquity of cattle bones testifying to the role of the live cattle in the economy, together with disposal of refuse from meat consumption, the animals themselves generally fail to attract discussion in site narratives outside the specialist report. Such marginalisation of cattle and their keepers extends to economic overviews. For example, Dyer (2002, 25), a standard text for economic history and later medieval archaeologists, gives this summation of earlier medieval cattle: "the cattle were by modern standards stunted – they probably weighed live about 440 pounds, half the weight of even a small modern breed. This lack of stature may be partly a comment on the cattle owners' failure to breed animals selectively, and partly on the feed and shelter available." Rather than perpetuating these negative stereotypes, this thesis places the live cattle herd back at the centre of the analysis and proposes new ways of interpreting the husbandry of cattle using the evidence of archaeological assemblages.

Fifty years ago, there was a major overview of cattle in archaeology entitled *Man and Cattle* (Mourant & Zeuner 1963), the gender-biased title reflecting its era. More recent research projects on cattle have focussed on individual elements of the herd, elucidating the inception of milch cows (Payne 2006, 54) and identifying draught oxen (Bartosiewicz *et al.* 1997) but little has been done to examine the individual constituents of the whole herd and the interplay between age and sex groups in husbandry and management. In part this is because most practitioners, if not almost all of them, lack any practical understanding of animals on the hoof and on the hook. This may be, as Francis Pryor (1998) suggests, because British archaeology is essentially an urban (or suburban) activity, studied by people who have lost contact with the countryside. Certainly, modern Western society is increasingly divorced from the kind of everyday contact with the agricultural cycle suggested by Lepoittevin's 19th century painting of a "Farm Girl at her Toilet", with the cow clearly shown at the foot of the bedstead (Plate 1.1)

Yet there is agreement that an understanding of live herds is invaluable for archaeological interpretation. O'Connor (2003, 72), for example, notes one stage in

the development of zooarchaeological studies as being to "investigate the animals themselves, to infer as much as possible about their appearance and biology". Study of cattle bones can enhance the understanding of the historical record for an archaeological site, resulting in integration the main site narrative, an approach endorsed by O'Connor (2000, 173-4) as a direction requiring further research. For O'Connor, the biology of domestic species is largely indissoluble from their husbandry and this approach is established for some prehistoric sites, such as Star Carr (Legge & Rowley-Conwy 1988) but is less well understood for domestic livestock in historic periods, as suggested by the title of Albarella's (1999) paper: "The mystery of husbandry". There is a difference between mystery or mistery, defined as "handicraft, trade" often in the form "art and mystery" and mystery defined as "hidden or inexplicable matter". Mistery in the sense of the epistemology of craftsmanship is explicitly debated in textile studies (Bender Jørgensen 2005, 67-8) but has yet to be routinely addressed in zooarchaeology, despite the obvious applicability to livestock husbandry. Mistery will be used in this explicit sense and one of the key themes to be addressed by this thesis is dispelling the mystery from the mistery, or verbalising the intuitive.

There are many benefits. For example, a major aim of zooarchaeological studies is to reconstruct the life and death assemblages of the species present, though it is generally agreed that an archaeological animal bone assemblage is but an imperfect reflection of these due to taphonomic processes (Klein & Kruz-Uribe 1984, 8). Both Jones and Ruben (1987, 197-8) and O'Connor (2003, 98-9) demonstrate that 6 cm is the size below which hand collection becomes an inadequate means of recovery. In practice this means that hand collected cattle bone fragments have been subject to a uniform selection process during excavation. Comparison of such assemblages is therefore comparing like-with-like in terms of recovery bias. By taking the theme of the cattle herd and its husbandry from the viewpoint of the management of the live animals for this thesis, it is intended to view the bones that end up being deposited in the ground from the other side of the whole range of taphonomic processes (Davis 1987, 22) that restrict the interpretations that are generally considered possible from archaeological faunal assemblages (Rackham 1987b). If there is more understanding both of the selection processes that generate the slaughter population from the live population and the requirements of, and restrictions on, the

consumers of the meat, then it may be possible to look for, and so detect, these patterns in the animal bones recovered.

1.1 Aims and objectives

The primary objective of this thesis is therefore to effect change in the archaeological analysis of assemblages of cattle bones by drawing upon new sources of evidence, much of which has hitherto been unavailable or disregarded. These sources will include:

- historical and pictorial sources, which will be used to establish contemporary attitudes to husbandry, usage and status of cattle;
- observations from modern husbandry and a live herd;
- and, the study of a modern reference collection of Dexter cattle skeletons of known age, sex and life history.

All these sources will be critically examined here and, to facilitate this, individual chapters will consider the individual constituents of a herd: the bull; the calves and growing young stock; the dairy cows; the suckler cows and the beefed cull cows; the oxen, both draught and fat. The overall structure for this thesis is influenced loosely by the concept of the Operational Chain, as used, for example, in textile studies and there defined by Thingnæs (2010, 235-6) as every step in the production of an artefact being potentially subject to cultural pressure and symbolic discourse. This concept of the 'biography' has also been extensively applied by archaeologists since it was first introduced nearly 30 years ago (Appadurai 1986), for example in studies of the material culture of needlework (Beaudry 2007) and the medieval life course (Gilchrist 2012). Studies which come closest to the subject of this thesis are perhaps Knusel *et al* (2010) and Lewis (2002) who examine respectively the life history of an individual human and cohorts of infants and children. For this thesis, the same approach is applied to the sequence of decision making involved in the rearing and culling of cattle, thereby incorporating social aspects into the analysis.

1.2 Major sources of data

i. Artistic and historical evidence

Artistic representations contemporary with archaeological finds of animal bones provide an opportunity to put flesh on the dry bones and endeavour to interpret human attitudes towards livestock of the time. *Books of Hours* and Psalters are rich sources of illumination of *Labours of the Months*, annual calendars of agricultural tasks including cattle, both ploughing and dairying (Perez Higuera 1998). The outstanding English example is the Luttrell Psalter (Backhouse 2000; Brown 2006a) though medieval bestiaries are also a fruitful source of images (eg. Barber 1999). Some fallibility may be demonstrated on the part of modern commentators who are unfamiliar with agricultural iconography, see Appendix 1: 1.

As for agricultural texts and later farming manuals, the prime text of the later medieval period is a late 13th century text known as Walter of Henley (Oschinsky 1971). Later treatises include that by Thomas Tusser in the later 16th century who is especially invaluable to the literate new entrant to farming (Hartley 1969), Gervase Markham who was writing in the early 17th century (Best 1986), Arthur Young in the later 18th century (Young 1771) and William Cobbett in the early 19th century. The advice provided by these authors tends towards the ideal but is nonetheless invaluable, albeit that the authors are, with the exception of Cobbett, socially elite males writing for their peers and therefore not representative of the husbandry practiced by the lower social orders and women. Further discussion of these sources may be found in Appendix 1.1.

ii. The Reference Collection of Dexter Skeletons

This thesis makes extensive use of the author's reference collection of Dexter cattle and, to justify this approach, some background is needed. The Dexter is the smallest surviving breed of cattle originating in the British Isles. The present breed is of relatively modern origin, being a 19th century offshoot of the eponymous Kerry breed of cattle, indigenous to Ireland (Pringle 1872). Curran (1990, 83-103) summarises the history of the two breeds in the later 19th and 20th centuries, firstly with a joint herd book then separation into two distinct breeds with separate herd books. This confusion arose because of a lack of understanding on the part of commentators that the difference in phenotype did not reflect a difference in

genotype. The Dexter phenotype is the result of genetic chondrodysplasia, a form of dwarfism. In simple Mendelian terms, the mating of two carriers of this gene results in one normal, non-carrier, long-legged or Kerry type calf, two short-leg, carrier, Dexter calves and one non-viable foetus, or bulldog calf, aborted before reaching term. Until the 1990s, the short-leg carrier phenotype was the official breed standard and calves of the long-leg phenotype were generally culled. The prevalence of the bulldog calf, caused by such a breeding strategy, threatened the viability and survival of the breed, resulting in the non-carrier cattle finally being accepted as of equal merit in the breed standard. Crossing a non-carrier with a carrier means that all calves are viable, with a Mendelian average of two long-legged to two short-legged. The mating of two non-carriers gives true to type breeding, with all progeny long-legged, or Kerry type. The association of the short-leg character with the Dexter is emphasised by the fact that non-carriers are referred to as "non-short" by Dexter Cattle Society (DCS, established in 1892).

In the 20th century both the Kerry and the Dexter became rare breeds with populations falling sufficiently low to constitute genetic bottle necks. The Kerry survived in Ireland while the Dexter became extinct in Ireland but survived in England. Despite the best efforts of the DCS to impose a breed standard, the range of conformation apparent in the non-carrier Dexters forward at the major breed sales in northern England in the 21st century is of great interest. A century of selection for uniformity in the carrier phenotype has effectively retained diversity in the non-carrier phenotype, which is now being expressed. The original Kerry breed has been subject to equivalent conformity to a breed standard, so there is now considerable disparity between the modern non-short Dexter and the Kerry. The Dexter may have inadvertently retained some of the range of phenotype originally present in the Kerry.

Kerry cattle have been generally considered a suitable comparandum for the smaller types of archaeological cattle found from the Bronze Age onwards in England. In the 1970s, Kerry cattle were not readily available in England, so non-short Dexters were obtained for the Iron Age farm at Butser, Hants. Reynolds (1976, 12) illustrates one of the Butser Dexter cows with the description that she has "unusually long legs". In fact, this is a normal non-short Dexter but the breed itself was then rare and non-carriers even rarer. Since the use of Dexters at Butser, the breed has become more widely accepted as a means of visualising the small cattle of antiquity. The legacy of the exclusive vogue for the carrier phenotype has been some

dismissal of the breed for archaeological comparison because of the manifestation of dwarfism. Such criticism in itself shows a lack of awareness of the prevalence of dwarfism within modern cattle breeds and indicates that dwarfism is not a character that is being actively recognised in archaeological assemblages. While the bones of sheep exhibiting the Ancon dwarf mutation are readily visible archaeologically (Gidney 2007a), the more fragmented bones of cattle render the separation of the dwarf from the merely small more problematic.

The author commenced keeping Dexter cattle in 1986, but breeding cattle is a very slow way of obtaining reference specimens. In 1988, the author commenced purchasing cull Dexter cows from other herds, for slaughter to obtain the skeletons. Active collection of such adult skeletons ceased in the 1990's. Incomplete skeletons from young stock reared for beef, including Jersey and Jersey crosses double-suckled on Dexter cows, were retained prior to 1997. Skeletons were also collected from natural mortalities, both the very young and the very old. The reference collection of some forty, mostly, Dexter skeletons therefore represents a "real" death assemblage covering natural mortalities, prime beef stock and aged culls from the breeding herd. The dates of birth and death are known for the animals, together with pedigrees covering five generations of ancestry. No institutional reference collection known to the author has a comparable number of specimens of this breed of known age and breeding and few, if any, institutions have actively collected cattle reference skeletons on this scale in the later 20th century. Recent studies such as Sten (2004) and Bartosiewicz *et al* (1997) have only collected selected body parts, respectively mandibles and feet, from abattoirs.

Besides the obvious task of elucidating what, if any, unambiguous post-cranial skeletal markers are present for chondrodysplasia, the prevalence of pathological conditions in the Dexters, particularly age-related arthropathies, will help to establish the aetiology of conditions, such as eburnation, or polishing on articular surfaces, in the hip joint, which are the subject of contrasting interpretations for archaeological finds. This collection of Dexters also provides a resource for examination of the prevalence of a range of non-metrical traits found in archaeological collections. These include congenital absence of mandibular premolar 2, the hypoconulid on molar 3, perforations in the occipital bones, foramina in ribs and vertebrae and depressions in joint surfaces, particularly in the bones of the feet. Although complete bones are present, only a selection of measurements has been taken, corresponding with the

robust elements that survive archaeologically. The opportunity is taken to compare the metrical data from the Dexters with factors commonly used to establish the gestation age of foetal calves and the withers heights of adult cattle. Complete skeletons also give the opportunity to compare the data widely used for ageing cattle bones from stages of tooth eruption and wear and epiphysial fusion with animals of known calendar age and management, for example castration.

The pertinent literature for all these points is discussed with the occurrence of the individual conditions in the following chapters. However, it can immediately be seen that a collection of complete skeletons allows for discussion of a number of conditions potentially present within one animal, which is not possible with the butchered fragments found in archaeological deposits.

iii. The archaeological sample

In terms of the archaeological material discussed in this thesis, the author has chosen to focus on medieval England and Wales with occasional diversions into the prehistoric and Roman periods. The approach is not intended to be comprehensive; this is not an analysis of cattle and their many uses. Rather these examples have been chosen because of the quality of data they present. To some extent there is a bias towards the hill country of the north of England, but this only serves to correct the overwhelming bias of faunal data presented and published from southern England and allows the author to select comparative exempla from assemblages analysed personally and therefore devoid of inter-operator variation in recording level. Romano-British sites include the fort at Wallsend (Gidney 2003), the villa and fort at Piercebridge (Gidney 2008) and the salt-making site at Nantwich (Gidney 2012). For the medieval and post-medieval periods there are large faunal assemblages from Leicester (Gidney 1991a &b, 1999), Shapwick (Gidney 2007b) and Dryslwyn (Gidney 2007c) besides a series of smaller assemblages from Newcastle upon Tyne (Gidney 1989a & b, 1994, 2001). This suite of sites covers the consumption of the produce of the classic manorial farming system of the English Midlands at Leicester; the dairy-based Hendre and Hafod pastoralism of Wales; the manorial farming of a major religious house at Shapwick and the hinterland of the cattle-reiving Anglo-Scottish border at Newcastle upon Tyne. Examples are also used of small assemblages from sites from north-east England seen only for assessment. Themes

identified during analysis of the cattle bones from all these sites acted as catalysts in forming research questions for this study.

1.3 Format of thesis

As mentioned above, the individual chapters in this thesis consider the constituents of the cattle herd by age and sex groupings. This approach is designed to lead to a better understanding of the husbandry of the live animals and the decision-making processes leading to selection for slaughter of animals of particular ages and sexes. From this, it can be suggested which data from archaeological assemblages can be used to interpret husbandry, rather than culinary, strategies. Situations where taphonomic factors mask the evidence for such strategies will be considered.

The discussion commences in Chapter 2 with the aurochs as the progenitor of all domestic cattle and the domestic stock bull who is, in the old adage, "half the herd". The calf and the growing young stock are then discussed in Chapter 3, as the decisions taken at birth over which calves to rear govern the subsequent composition of the herd. The dairy cow is considered in Chapter 4, having been the prime source of protein for the majority of the human population in the form of "white meats" or dairy produce. The end use of the cow as beef is a major source of the bones found in the archaeological record, so the opportunity is taken in Chapter 5 for detailed metrical comparison of the Dexter cow skeletons with archaeological finds. The ox was originally the prime source of agricultural traction power but Chapter 6 also discusses the post-medieval ox as a purely beef animal and the concept of livestock improvement. Chapter 7 reconsiders the results in the light of the aims and objectives set out above and provides an overview of the most valuable points raised by this project for consideration during the production of routine analyses of faunal remains from archaeological sites.

Within each chapter, the contents have been standardised. Firstly, it is shown how the integration of information from historical and modern sources pertaining to husbandry can give insights when reconstructing herding strategies from archaeological assemblages of cattle bone fragments. Secondly, the modern Dexter breed will be taken as a comparandum for the small cattle represented on British archaeological sites from the Bronze Age to the early 19th century. Data from these modern animals can inform estimations of, for example, milk yield from cows and

variation in calf birth weights. In particular, observations made in the author's Dexter herd will be used to substantiate points arising from discussion of the husbandry sources with complementary data being derived from the author's own reference collection of Dexter skeletons of animals of known age and life history.

This unique resource will then be used to challenge currently accepted hypotheses on, for example, the aetiology of congenital and pathological conditions. The nature of dwarfism in the Dexter will be discussed in relation to archaeological cattle of similar conformation and possible reasons for human selection of dwarf carrier cattle will be proposed. It will be suggested that negative views of small cattle have led to a lack of appreciation of the possibility of dwarfism in archaeological cattle and hence the lack of any active research to identify and quantify the occurrence of dwarfism, let alone use aDNA to identify the specific gene or genes expressed. Metrical data from the Dexter skeletons will be used to ascertain how similar in stature cattle from a range of archaeological sites were to the Dexter. The known sex Dexter metrical data will be used for comparison with archaeological data believed to indicate culling of dairy cows. The known size range of the Dexter will be used to challenge interpretations of "improvement" in cattle size prior to the 18th century.

Chapter 2: The Aurochs and the Domestic Bull

The extinct wild aurochs, *Bos primigenius*, was the progenitor of all modern domestic cattle. The success of domesticated cattle, *Bos taurus*, under human management is in inverse proportion to the wild ancestor, whose relic population was reduced to one herd in Eastern Europe which died out in the 17th century. This chapter will commence with speculation on some of the possible mechanisms contributing to the morphological change from aurochs to domestic cattle and the success of domestic cattle under human management compared to the decline and extinction of the wild aurochs. The role of the domestic bull will then be discussed.

2.1 The Legacy of the Aurochs

i. Diminution from the aurochs to the Dexter

An important topic to consider at the outset is how natural selection and human impact on wild aurochs and early domestic cattle might have contributed to the diminution in size from the prehistoric aurochs to the modern Dexter. Researchers working in more recent historical periods frequently disassociate domestic cattle in northern Europe from the ancestral aurochs, impressive cattle with mature Holocene bulls once thought to have a shoulder height approaching 2m but now believed to be in the range 1.6-1.8m for bulls and about 1.5m for cows (van Vuure 2005, 110-120). This is the latent default size for all domestic cattle descended from the aurochs, however the small size of the domestic cattle bones found archaeologically and the survival of small breeds, such as the Dexter, to the present day demonstrate that such large size, *per se*, was not necessarily a required or desired attribute of domestic cattle in the past. Rather than an increase in size, prehistoric "improvement" in domestic cattle was in achieving the reduction in size from the aurochs range to the small cattle widespread into the early 19th century.

That divergent breeds from different countries could rapidly revert to a true-breeding aurochs phenotype was proposed by the Heck brothers (1951) using parallel breeding programmes at Munich and Berlin zoos, prior to World War II. More recent evaluation of this breeding programme (van Vuure 2005, 345-350) suggests that the Heck brothers' claims were exaggerated and influenced by the contemporary political

climate. The descendants of the Munich experimental animals are known today as Heck cattle, rather than bred-back aurochs, to distance and distinguish the modern animals from the extinct wild aurochs.

Two small modern cattle breeds, the British Dexter and Swiss Herens (see also Chapter 5), which were not used by the Heck brothers, also carry the wild-type red coat variant that is believed to be aurochs colouring and seen in Heck cattle. The calf is born a pure bright red. Subsequently a bull calf turns almost black with a reddish tinge to the coat, a red eelstripe down the centre of the back and a white muzzle, while a heifer has a red brindle coat, which can shade into black. The survival of this colouring in two geographically diverse breeds of similar small stature is a reminder of the communal ancestry from the aurochs.

Eminent authorities, among them Dyer (2002) mentioned at the start of Chapter 1, have attributed the diminution in size of domestic cattle to either "malnutrition and inadequate keeping in the main growth period" (Teichert 1993, 236) or "the loss of night-feeding (which) has a very deleterious effect on ruminating animals such as cattle that are physiologically adapted to periods of grazing followed by periods of rumination" (Clutton-Brock 1981, 68). These malnutrition proposals to explain the decline in size of domestic cattle fail to consider that a low plane of nutrition over the winter was largely compensated for by catch-up growth after turn out in spring (Duckham 1963, 275-7). Similarly, the Soay sheep on Hirta show a pronounced annual cycle of rapid weight loss from October to January with a correspondingly rapid recovery of live weight during spring and early summer (Doney *et al* 1974, 102). In the medieval period, the importance of the waste as a grazing buffer for the manorial livestock has been demonstrated by Rippon (2004) and Britnell (2004). Summer grazing systems such as Shieling in northern England (Winchester 2000) and the Hafod in Wales (Hartley 1985, 467-8) would also have provided ample grazing for such rapid recuperative growth in spring. Malnutrition is therefore possibly not a root cause of diminutive domestic cattle. Rather it seems possible that the provision of supplementary fodder to domestic cattle might inadvertently result in an overall decline in herd size as the smallest animals, which would not survive the winter in the wild, could enter the breeding pool, with subsequent long-term effects on mean body size.

ii. Bergmann's Rule

Examples of miniaturisation have been observed in wild animals, without any impact from humans, with prime examples being island populations (Lister 1989). Ozgul *et al* (2009) have identified the processes resulting in a recent decline in the body size of the Soay sheep on St Kilda. Here, the less frequent occurrence of long harsh winters has increased the survivability of small slow-growing individuals, who are breeding at a younger age and producing lambs of lighter body weight. Consequently, there is now a reduction in the mean body weight of the population. In the 19th century, Bergmann also observed an inverse correlation between latitude and body size, related to temperature (Davis 1981, 110). Davis (1981) provides detailed evidence for diminution in a range of species coinciding with the temperature elevation 12,000 years ago. The aurochs of the post-glacial climatic optimum would therefore be expected to be of smaller size and body mass than the late glacial animals. The St Kilda example demonstrates the speed with which such a shift in parameters of size and weight, driven by environmental change, can occur in an isolated population. This has interesting connotations for the mechanisms of changes in the conformation of early domestic livestock.

Sykes (2007, 50-51) suggests that climate change may be a contributory factor for the change in the size of cattle observed between Roman sites of the 3rd-4th centuries AD and post-Roman sites of the 5th-10th centuries AD. However, Sykes suggests that large cattle reflect warm conditions in the earlier period and small cattle are a response to climatic deterioration in the later period. This is a complete reversal of Bergmann's Rule, that large body size is a response to a cold environment. While climate and local environment must exert selection pressure on domestic livestock, if Sykes' interpretation is correct, human selection may over-ride the natural selection response to such variables.

However, *contra* Sykes, an example will now be considered of a phenomenon identified as a phase of increase in cattle size. Albarella and Davis (1996, 42-57) discuss the appearance of larger cattle at Launceston castle, Cornwall, between period 8, 15th century and period 9, 16th century to 1650. The change in both size and shape of cattle bones is described as "dramatic", comparable to the sudden appearance of the massive phenotype in 18th century deposits, discussed in Chapter 6. Albarella and Davis consider a range of possible causes for this change, including changes in sex ratio and castration, and conclude that a change in genotype is indicated. Evidence for

similar change on a range of contemporary sites in England is presented. The literary evidence for both cross-breeding between indigenous regional cattle types and the import of Dutch cattle are discussed, together with the opinions of agrarian historians. The consensus is in favour of deliberate "improvement" in the more stable period of Elizabeth's reign.

While this is a seminal discussion of the evidence, one point was not explicitly considered. This is Bergmann's Rule in relation to the "Little Ice Age" of the 16th century. Armitage (1994, 236-8) drew attention to the "extraordinarily large size" of black rat bones found on later medieval and early Tudor archaeological sites in Britain. Both the large size and black pelage are believed to be an adaptive response to this cold period. No-one would describe this sudden and dramatic increase in the size of rat bones as either evidence for "improvement" or for selective breeding on the part of humans, yet this change is contemporary to that seen for the cattle.

Earlier records demonstrate the mortality of out-wintered cattle resulting from severe winter weather. In the 14th century, 21 of the out-wintered desmesne cattle of Barnard Castle died in the hard winter of 1324-5 (Austin 2007, 105). Tusser's later 16th century recommendations for February's husbandry also indicate out-wintering of cattle (Hartley 1969, 132).

Rats obviously have a far faster reproductive rate than cattle and so might be anticipated to show a more contemporary morphological response to the deteriorating weather of the "Little Ice Age". Increased mortality of out-wintered, small and lean cattle would of itself enhance the representation of larger cattle in the breeding pool. Observation of this fact and selection for it by deliberate breeding and importation of Dutch cattle may have been part of the dynamic stimulating the increase in cattle size observed by Albarella and Davis. It is therefore possible that this size "improvement" was initially driven by natural selection operating under Bergmann's rule, and a pragmatic reaction to mortality of smaller breeding stock, rather than the inception of conscious breeding of larger animals for enhanced carcase return.

The "giant" black rats of the 16th century and the "shrinking" Soays of the 21st century both indicate that fluctuations in the size of commensal and feral animals can occur as a rapid response to changes in weather patterns, without human intervention by selective breeding. Domestic cattle that were not inwintered and were given little supplementary feed in winter would be subject to the same selection pressures. In a time period of severe winter weather conditions, the appearance of

larger animals should be expected. Conversely, an era of mild winters should be equally reflected in a decrease in stature. Neither process should invoke recourse to such eugenic expressions as improvement and degeneration, as both phenotypes are physical expressions of adaptation to contemporary circumstances.

iii. The Trophy Head

An alternative scenario for diminution is interference with the genetic make-up of the population by removing breeding males. Such an impact may well have been inadvertent, rather than intentional, as the pursuit of the trophy head of male animals bearing horns, antlers or tusks remained fundamental to hunting into the 20th century. The antiquity of the practice may be indicated by male gazelle horn cores collected "certainly for other than dietary reasons" on Natufian sites in the Levant (Tchernov 1993, 198), associated with large numbers of phalanges. Similarly, for PPNB sites, given the wide range and solitary habits of the male ibex, Tchernov (1993, 204) notes as a "surprising anomaly" the frequency of ibex, which can approach that seen for male Natufian gazelles. The pattern of cranial elements, metapodials and phalanges (Tchernov 1993, 202) suggests skins with heads and feet attached, though this was not considered by Tchernov. "Ritual" display of skins with heads and hooves is well attested from later prehistoric sites in western Europe (Piggott 1962). O'Connor (2000, 91) provides a caution that some interpretations of slaughter patterns may appear "alien to a modern mind attuned to notions of economic productivity". The evidence summarised by Tchernov could be taken to indicate that trophy hunting of mature male ungulates was an integral part of Natufian and PPN societies in the Levant, for reasons beyond the mere provision of food. The Levant was not prime habitat for aurochs, even at these early periods, but it seems plausible to transpose the predilection for trophy heads and hides of male gazelle and ibex to the aurochs, where that was the most spectacular male ungulate available.

Cope (1991) also identified preferential slaughter of male gazelles on Natufian sites in the Levant, coupled with extreme diminution, particularly of astragali, distal metapodials and first phalanges. Cope (1991, 356) suggested that a hunting pattern preferentially targeting males would impinge on natural selection through female choice and parallel the result of reproductive isolation, seen for island populations. While subsequent research (Bar-Oz *et al* 1999 & 2004) has failed to substantiate Cope's proposal for wild gazelle, it remains an interesting hypothesis to account for

the size reduction of prehistoric cattle, if aurochs bulls were subject to comparable hunting pressure.

The spatially and chronologically widespread display of aurochs and domestic cattle bucrania, from Çatal Hüyük (Mellaart 1975, 108-9) to later religious iconography from Egyptian, Minoan and classical Roman sites, attest to ritual connotations associated with the display of bucrania. Exhibition of these trophies from hunted or sacrificial animals could suggest that a major impact of human manipulation of livestock populations may have been the explicit removal of sires from the breeding pool, rather than deliberate selection of males to breed from.

The records of the last wild aurochsen, kept in a royal hunting park, show this relict population was subject to such continued hunting pressure: “the one animal that they have noticed to be stronger, and constantly provoking others to fights, hunters will hunt under orders of the king” (van Vuure 2005, 269). The extinction of the wild aurochs in 1627 suggests that this hunting strategy was detrimental to their long term survival. The killing of the "King Bull" of the Chillingham herd of wild white cattle is a recent example (Whitehead 1953, 51-2; Hall & Hall 1988, 482) of such an approach to cattle. Here, human interference in herd sire selection was both by removal of the senior sire, allowing the second ranking males to battle for supremacy and breeding opportunity without further human intervention, and castration of some junior males. This contrasts with the breeding of modern domestic bulls, where the majority of junior males not required for breeding are castrated. The latter approach puts the human in total control of selection of, usually one, stock bull for breeding.

The contrast is therefore between a "trophy head" hunting, or religious offering, strategy which removes one or more selected senior males, who had achieved their ranking by natural selection, from the breeding pool *and* a domestic breeding strategy which introduces one humanly selected sire for mating. In both cases, human manipulation of the males allowed to breed may be reflected in the genotype and phenotype of subsequent generations. This example is a contribution to the speculations invited by Hall (2004, 9) on the possible mechanisms of domestication.

Also of relevance to trophy head exploitation of males is Geist’s (1971, 180) observation for sheep that males with vigorous horn growth reach breeding status earlier but die younger than rams with poor horn growth. It could therefore be argued that the “best” heads may be found on animals with a relatively short life expectancy,

which might therefore be expendable as sacrificial offerings. Conversely males with poorer horn growth live longer and, in a situation where larger horned rivals were removed by human agency, would have a longer term contribution to the breeding pool.

While the hunting strategy is of marginal relevance to the more recent archaeological case studies and modern Dexter comparanda to be discussed, it is vital to be aware that the continuance of small cattle reflects ongoing active selection *against* large sires for breeding. Had larger sires been allowed to reproduce, a rapid reversion towards the aurochs phenotypic size would result, as seen in the many modern massive commercial cattle breeds. "Improvement" in terms of an increase in size may therefore be seen as removing the brake of selecting *for* diminution, whether intentional or not, while any subsequent decrease in size reflects an active breeding policy of sire selection to achieve this end.

iv. The Ungulate Paradox

Build and size are integral to the Ungulate Paradox articulated by Geist (1971, 14) in relation to wild sheep, but the general principle holds true for all ungulates, including cattle:

"Body and horn size, age at sexual maturation, behavioural vigour, as well as life expectancy, depend on the quality of a sheep population. The larger and finer the animals, the more vigorous the rams and the more fertile the females, the shorter is their life expectancy. There is an apparent paradox that the 'better' the sheep the quicker they die."

While this concept is understood by zoologists, it is not widely discussed in relation to breeding ancient or modern domestic animals. It is the fundamental flaw in all concepts of post-medieval livestock breeding for "improvement" using only visual parameters. Any breeding strategy that values longevity as a desirable trait is not going to produce the "large and fine" animals, conversely a strategy that aims to produce "large and fine" animals will do so at the expense of longevity, as seen in the modern Holstein. This may be one rationalisation for the sacrifice of the "best" animals.

That denigrated "runts" can have higher survivability is demonstrated by studies of the Soay sheep (Gratten *et al* 2008, 318-320) and the continuing survival of all such animals, despite the best efforts of the "improvers" to exterminate them. Even

Galton (1907, 16-17), who coined the term "eugenics", understood that stamina and adaptation to local conditions were not linked to outward appearance, with the "shabby-looking, sickly-looking and puny" having advantage over "the most shapely, biggest and much haler".

Whatever desirable traits the live animal had, all the zooarchaeologist can quantify is body size. There must have been a perceived correlation between overall herd body size and required production traits for the small size of domestic cattle to have remained relatively constant over so many centuries.

v. The Rut or Breeding Season

The size of the selected herd sire may also have unforeseen consequences on the seasonality of breeding. Both Heck (1951, 119) and van Vuure (2005, 264-271) argue that, from historical information on the last surviving population of aurochs in Poland and comparison with other wild bovines, the aurochs had a clearly defined rut in August-September giving calving in May-June. This contrasts with the unmanaged feral domestic Chillingham cattle, for which Hall & Hall (1988, 483) have demonstrated a year round breeding pattern. Van Vuure (2005, 270) suggests that the Chillingham cattle breed aseasonally because they are provided with supplementary fodder in winter. This suggestion partly misses two points. The last living aurochs herd had been marginalised from their preferred habitat, which Hall (2008) suggests for the Holocene population in Britain would have been lush riverine environments with ample fodder. Also, like the Chillinghams, the remnant population of aurochs was fed hay in winter.

All domestic cattle today, whether managed on intensive or extensive systems, whether dairy or beef breeds, whether in cold, wet or arid climates, whether in northern or southern hemisphere, whether at high or low altitude, can breed all year round (Hall 1989). It seems quite remarkable that domestication alone could have effected this, when sheep, which have been under domestication for far longer and are kept under the same range of variables as cattle, remain seasonal breeders. The aurochs must have had the latent capability to breed outside the main rutting season and van Vuure (2005, 269-70) does cite instances of aurochs calves born in September, indicating mating in December. Captive European bison can also breed throughout the year (van Vuure 2005, 270) which suggests that this is a more general bovine trait. Van Vuure (2005, 109) mentions, but does not expand on, a far more

plausible explanation for out of season breeding, which is the pronounced sexual dimorphism seen in the aurochs. This is characteristic of species where the adult males only join the females and juveniles during the mating season. If, as postulated above, human manipulation of wild or managed herds had a strategy of removing "trophy heads" or "King" bulls, the males allowed to breed could become progressively less markedly dimorphic from the females and junior bulls, still running with the female herd, could gain opportunities to breed.

One could also propose that marked sexual dimorphism and a clearly defined rut in the wild could be a response to higher latitude and an environment with adverse winter conditions, with the potential for extended breeding opportunities in lower latitudes with less strongly defined seasons and cattle of smaller body size, in accordance with Bergmann's Rule. Human removal of senior breeding bulls could therefore impinge on the seasonal rut and stimulate out of season breeding. As previously noted (van Vuure 2005, 120), there was a far greater range of withers heights, 1.6-1.8m, for the aurochs bulls than for the aurochs cows at 1.5m. If the larger than 1.6m tall bulls were to be removed by human agency, then the *circa* 1.6m bulls could mate with the 1.5m cows and realise this proposed scenario for extending the breeding season to that seen in domestic cattle. This would have been a wholly inadvertent side effect but the lack of extreme sexual dimorphism in height could be an explanation for aseasonal breeding in Chillingham cattle. Although modern domestic cattle still exhibit sexual dimorphism, this is more of a contrast between robust and gracile build rather than absolute size, for example the Dexter bull and cow in Plate 2:1, now in the reference collection.

2.2 The Domestic Bull

The bull is the first constituent member of the domestic herd to be considered in detail; his influence is paramount since the bull passes his genes to every one of his calves, whereas the cow contributes to only one calf annually (Morley 1950, 58-9). The bull therefore determines the calibre of a whole generation of calves and the selection of a stock bull can make or mar a herd. In this chapter the stock bull is referred to in the singular as there is usually only one breeding male to several cows, calves and steers in a domestic situation, or a restricted number of senior breeding males in the wild.

2.3 *Historical Information*

i. Sire selection

Section 2.1 has demonstrated the potential far-reaching consequences of interference with the natural order of bulls allowed to breed and how the resultant drift in the population parameters may have been an unexpected, rather than intended, consequence of such interference. Later husbandry manuals had different ideas. In the 17th century, Markham recommended that the bull should not be of a different type to the cows but should be either of comparable origin or shape and colour (Best 1986, 167). Markham strongly advised against mixing cattle of different kinds and this prejudice continued as Darwin (1872 facs., 23) also reported that "the breeders are strongly opposed to this practice". Markham (1616, 87) however acknowledged that cross-breeding different regional races of cattle did occur and that in such case it was preferable to cross either red with red or black with black, than to cross red with black. Markham (1616, 87) further gives a detailed list of the points to look for in a breeding bull. With the exception of a high tail head, the description of Markham's ideal bull is still valid today.

It is of particular note that Markham (1616, 87) observed that the breeding bull was also " excellently good for the draught, onely they naturally draw better single, like horses, then in the yoake, like Oxen". Fenton (1969, 33-9) gives examples of 18th century hill farmers in Scotland using the bull in the yoke and in 1819 Cobbett published a diagram for making a yoke for a single ox, based on an example seen in America to harness a bull (Cobbett 1983, 96). Plates 2: 3a-b illustrate that males are still yoked individually for draught in the Far East. The use of the breeding bull as a draught animal, when not needed for mating, has interesting implications. This could, in part, explain why bulls do not appear in the paines regulating the stock on upland grazing, unlike stallions and rams (Winchester 2000 and pers. comm.). Separating the breeding bull from the draught ox on the basis of morphological changes to the skeleton possibly caused by draught work would clearly be impossible. Understanding the use of the live animal is therefore necessary before formulating and implementing such research questions.

One of the accusations levelled against traditional husbandry was the concept of the stock bull being "nobody's son", in comparison to the known lineage of the pedigree bull, promulgated as "half the herd". In fact Chapter 3 will demonstrate that rigorous selection was applied to those calves deemed suitable to rear and, as seen above, all males may have been left entire until an age where informed judgement on conformation and temperament could be made. Heifer calves raised under this system would all have the potential to be dams of bulls. As noted in Appendix 2: 1, some of the bloodless bull sports use the principal of the King Bull in the selection of a breeding sire and involve communal participation in the process. While the individual parentage of a sire selected under this system might not be known, the "nobody's son" approach actually follows the principles of natural selection in the wild. The bull proves his own merit in open contest, without reliance on the hope that he will transmit desirable attributes apparent in his parentage. In contrast pedigree breeding, despite the ongoing propaganda, has several inherent flaws. Top breeders can be motivated by financial gain, "profit", leading to irregularities in pedigree recording that are now coming to light with the increasing use of DNA tests as part of the sire registration process. Pedigree breeding uses inbreeding and line breeding to fix desirable types. However, these equally fix undesirable types and the widespread use of particular sires, or sire lines, rapidly spreads genetic defects, which are subsequently hard to eliminate. None of these conditions would occur with any regularity with the use of "nobody's son".

The pedigree bull does not have the sole distinction of being viewed as "half the herd". The acquisition of the Brown Bull of Cuailnge for Medb's herd, since of all their possessions her husband Ailill's bull, Finnbennach, was the only item superior to her own, is the starting point of the epic Irish saga the *Tain Bo Cualilnge* (Kinsella 1969). This concludes with a fight between Finnbennach and the Brown Bull to establish, in full view of the assembled armies, which was the superior animal by combat between these "King bulls". The judge was trampled to death, Finnbennach was killed and the Brown Bull died of his injuries. Despite being the basis of the entire saga, neither bull has an individual name, merely a name descriptive of an attribute. Finnbennach simply means the "white-horned one", as opposed to the "brown" bull.

Irrespective of the value placed on these bulls, they were still cattle, or one of many. Not until the 18th century inception of pedigree recording do outstanding

animals receive individual, rather than descriptive, names. In the early pedigrees, the breeder or owner was identified rather than the individual bull and even the pedigree of the famous Shorthorn bull Comet, Figure 2: 1, rapidly traces back to an unknown bull. The Colling brothers got the publicity and made the money from their Shorthorns but their foundation stock were largely bred traditionally by people and from animals who were generally unknown, and so received little credit in the ensuing hype. For example the bull Hubback was bred by Mr Taylor, a brick layer, while the sire of Fuljambe was merely "Mr Richard Barker's bull" (Proud & Butler 1985, 31).

Until the stock bull was given an individual name, there could be no "improvement" in the modern sense of pedigree breeding and recording of the transmission of heritable attributes. Every bull was in effect "nobody's son" as there was only reference back to the owner, who was not necessarily the breeder, or the mart where the bull was purchased. This is a further reason why giving the label "improvement" to changes in cattle morphology prior to the 18th century conveys a misleading impression of the causes and motivation for such change.

ii. Management of breeding

Historical evidence for the timing of running the bull with the cows is vital for determining whether the archaeological record will show evidence of seasonality in calving. As seen above, domestic cattle, unlike deer and sheep with very seasonal breeding, can mate and calve throughout the year. Seasonal evidence of calving may therefore reflect human management. The medieval author of the *Seneschaucy* recommended that the cowherd should have "fine and big bulls, well matched, near the cows to mate when they will" (Oschinsky 1971, 283), which suggests the opportunity for year round breeding. There is evidence to show that attempts were made to control the calving season to coincide with the spring grass. One instance is known of the bulls only being run with the cows from May to November, which would produce calves from February to August; another example gives the dates for the bulls to run free from August to February, giving calvings from May to November (Sheringham 1982, 702).

Fussell (1966, 58-9) notes that the early post-medieval bull should be fat and strong for breeding and to this end should be given extra food for a couple of months previously. However heifers being served for the first time should be covered by a bull of three years old, as a mature bull would be too heavy for them (Fussell 1966, 15

& 59). Recommendations for the working life of a bull in one herd vary but one suggestion was two years (Fussell 1966, 64), comparable to the reign of a King Bull. Changing the bull after two years would avoid inbreeding on his own daughters.

Cattle-raiding was integral to medieval Welsh society and the *Laws of Howel Dda* codify which animals of a successful foray should be distributed to specific officers of the court, with one receiving "the bull which shall come among the spoil" (Wade-Evans 1909, 176). A bull features in the trial by ordeal of a woman seeking recompense following desertion after a clandestine affair, who has to attempt to hold "a bull of three winters" by its shaven and greased tail (Wade-Evans 1909, 241). The uncertain temper of the breeding male is recognised "three animals whose acts towards brutes are not cognizable in law during their rutting season: a stallion; and the bull of a trevgordd; and a herd boar" (Wade-Evans 1909, 274). While the law stipulates the regular increase in value of a "he-calf" from its birth until it is yoked in its fourth year (Wade-Evans 1909, 219-20), detailed in Chapter 3, the assumption appears to be that the "he-calf" grows into a plough ox. It is not clear when the "he-calf" is castrated. The ready availability of a bull of three winters, in the case above, may indicate that castration occurred in the fourth year, prior to being yoked in February. The northern dialect word 'stot' can indicate either a young bull or ox/steer or, more explicitly, one of three winters, discussed further in Chapter 3. In comparison, the rarity of entire adult breeding males is emphasised by their value: "three animals there are whose teithi exceed their legal worth: a stallion; and the bull of a trevgordd; and a herd boar, for the breed is lost if they are lost" (Wade-Evans 1909, 282). The bull of a trevgordd is roughly equivalent to a parish bull and the teithi is the innate value of an unblemished animal. This passage is suggestive of the adage of the bull being "half the herd". Markham (1616, 86) certainly understood this point, considering that the "choice of a fayre Bull" was "the breeders principallest instrument of profit". Though note that Markham's concern was with profit, or return on the capital invested in the animal, rather than any concept of "improvement" in the progeny of the bull.

The 1325-6 account roll for Barnard Castle (Austin 2007, 105) lists three bulls in the desmesne herd for 77 breeding cows and 18 barren cows but also 33 castrated bulls and 60 oxen and steers. This suggests that a large proportion of the young male cattle were left entire until informed decisions could be made on which ones to retain for breeding. The high number of cows to bulls may be even higher if the desmesne

bulls also had to cover the leased vaccary cows. Individual stock bulls would therefore have had a major influence on the succeeding generation of cattle.

McHardy's (2004) compilation of traditional stories about Scottish highland cattle-raiding includes only one example where a bull is described: "a young bull, just growing into his prime, who was as good as wild". This bull charged, and gored to death, the chieftain of the clan who had stolen the cattle, who was guarding the gateway of the cattle-fold. The bull then led the herd, consisting of younger bulls, cows and calves, back to their home pasture (McHardy 2004, 172-3). The composition of the herd is of note as including younger bulls but not steers. All these examples suggest that the selection of a potential breeding bull could be made from a pool of entire young males. The Scots example also may imply that the bull in British cattle-raiding societies, particularly when the wolf was still part of the indigenous fauna, was chosen for qualities comparable to those advocated for Spanish fighting cattle, discussed in Appendix 2: 1; the behaviour of the Scots bull also shows that he was hefted to his home pasture.

The *Laws of Howel Dda* also clearly demonstrate that the white cattle at Dinevwr, the chief residence of the rulers of Deheubarth, were well established prior to the 12th century, in contrast to the postulated 12th century origin for the Chillingham herd (Bilton 1957). The association of these cattle with the ruling family is unambiguous: "the status of the Lord of Dinevwr moreover is upheld by as many white cows, with the head of each one to the tail of the other and a bull between every score kine of them, as shall extend completely from Argoel to the Court of Dinevwr" (Wade-Evans 1909, 147). One bull to twenty cows recurs as a standard ratio, Fussell (1966, 61) notes this as an early post-medieval norm and it is broadly comparable to the 3:50 of the Spanish *corrida* bull breeding herds (Lewine 2005, 52). Unfortunately the distance from Argoel to Dinevwr is unknown (Whitehead 1953, 85), though Wade-Evans (1909 326) suggests a place name for Argoel about 2.5 miles away from Dinevwr. While the size of the herd is not known, the implication is that it was extensive. Taking Wade-Evans suggestion as a possibility, and assuming the length of non-short Dexters in the Zanfara herd to be similar, would suggest in the order of 1600 cows and 80 bulls. The size of such herds of white cattle is also indicated by Maud de Breos, of Hay on Wye castle, sending 400 cows of this colouration to appease the English crown in 1210, but only one bull (Harting 1880, 222). This strongly suggests that the bulls may have been of greater value in maintaining the

status of a Welsh or Border lord on the diminution of the herd. In comparison with the speculative computation for the Dinevwr herd, Maud's gift could represent a quarter of her herd, enough to make a munificent gesture but leaving sufficient to maintain the breeding stock. That the Breos and Dinevwr/Dryslwyn families were of commensurate status is demonstrated by subsequent intermarriage (Caple 2007, 21). Hemming (2002) summarises the symbolic identification of white park cattle with their aristocratic owners.

One final, but particularly interesting, aspect of breeding is that related to bull sports. The natural selection combat between senior males to establish breeding rights and the religious associations of the entire male have spawned a range of bull sports over the millennia. Once such sports became part of a monetary economy, such as the Roman amphitheatre, there would have been a financial incentive to breed appropriate animals yet the sporting bull is not a scenario which is normally considered in the interpretation of bone assemblages. Modern concepts of economic productivity from faunal remains (O'Connor 2000, 91) generally fail to consider working uses of cattle beyond milking cows, draught oxen and the stock bull.

Appendix 2: 1 presents some of the diversity of ancient and modern evidence for the sporting use of the live bull, which may suggest possibilities for future interpretations of archaeological data. Points to emphasise from this overview are:

- the strong link between bull sports and religious festivals, particularly those associated with agricultural fertility;
- bull sports are performed at a developmental stage when both men and bulls need to establish a dominant position in their social rank hierarchy to achieve breeding rights. Bulls that are killed at this selection stage are still considered prime beef, in contrast to the adult breeding bull;
- some aspects of bull sports may be performed only by either patrician or plebeian participants but these can form complementary parts of the overall spectacle.
- mounted blood sports are generally associated with the nobility and the associated hunting and military ethos;
- bull sports are dynamic, responding rapidly to cultural changes and opportunities to generate profit from the spectacle.

iii. Husbandry

Markham makes it clear that, in the late 16th-17th centuries, the selection of the bull to cover the milch cows was the province of the housewife in charge of the dairy (Best 1986, 167). This may seem a very minor point but in fact the gender of the people with control of cattle breeding has several far-reaching consequences. At a very simplistic level, there is a fundamental difference between "girl's toys", the dairy, and "boy's toys", the plough and, subsequently, specialist beef. In Chapter 4 the association of women with small cattle with good udder conformation, will be considered while in Chapter 6 men will be seen to admire large, fat animals.

Women and children may be safer with a bull because of the natural behaviour and herd structure of cattle. In common with other sexually dimorphic ungulates, outside the mating season the aurochs appears to have separated into herds composed of females with calves and young bulls while the mature males separated into small groups or became solitary (van Vuure 2005, 266). In such a situation, the bull grows up first subject his dam and then to the matriarch leading the female herd and therefore will be used to submitting to a dominant female. This is paralleled in a domestic situation where women run the dairy, as the bull calf will have been hand raised after weaning from his dam, discussed in Chapter 3.

In contrast men, particularly younger men, correspond to the bull's peers and their ongoing interactions to achieve dominance and ascend the social hierarchy. This is demonstrated by Whitlock (1977, 138-9) describing the relationship between the dairyman and the bull on his farm as "it was war between them", whereas his wife was able was able to stop, and drive back single handed, a strange bull that had escaped and was terrorising the village. About 1790, Bewick illustrated a countrywoman who also appears not to be intimidated by the bull barring her passage over the stile, Plate 2: 2a, in contrast to Bewick's depiction of a man running from a bull in Plate 2: 2b.

Land enclosure, particularly in the 18th-19th centuries, allowed control of livestock in separate fields giving the opportunity for planned matings of specific animals in a way that was not previously possible in the unenclosed open field and communal pasture situations (Minton 2002, 232-3). It is no coincidence that the earliest ideas of pedigree cattle breeding, where both parents are known, date to the late 18th century and the rise of enclosure, as exemplified by the title of Hall and Clutton-Brock's (1989) book *Two Hundred Years of British Farm Livestock*. It is

therefore inherently unlikely that evidence for improvement, in the modern sense of pedigree breeding, will be found predating enclosure.

Although enclosure in the 16th century was heartily endorsed by Tusser (Hartley 1969, 178-182), nowhere in his eulogy for the practice does he mention control of mating groups of farm livestock. As noted for the Ancon sheep (Gidney 2007a), the 16th century agricultural mindset does not appear to have viewed either a spontaneous mutation or enclosure as opportunities to manipulate livestock breeding in the manner that these were seized upon two hundred years later. Some of the economic reasons creating the market demand for the 18th century cattle breeders have been discussed by Gidney (2009).

Enclosure allowed the bull to be kept secure and separate from the rest of the herd when he was not working. This was an error in husbandry that would have been unknown beforehand. The penning of the bull by himself could lead to a deterioration in temperament, shown in Plate 2: 2b .This type of humour is not seen in earlier illustrations as the bull was not alone in a field. Late medieval depictions of aurochs bulls tossing armoured knights (Van Vuure 2005, 90, Fig. 14) were used to illustrate their fierce nature, by implication in contrast to the domestic bull.

The late 18th century saw the inception of a new niche market within livestock husbandry, that of the specialist breeder of pedigree sires for sale or hire to commercial farmers breeding primarily to produce meat for the urban market (Hall & Clutton-Brock 1989, 13). Today, these men would be described as "agribusinessmen". They were educated and articulate and it was in their own interest to advertise their stock and denigrate the indigenous cattle types and associated traditional breeding and management practices. So successful was this campaign of propaganda that it was largely unquestioned throughout the 19th and 20th centuries, resulting in the extinction of many native livestock breeds. "Improvement" continues to be repeated as an unquestioned mantra by most modern breed societies. The economic reasons for this remain the same but on a global scale, with the world-wide distribution of semen from a few specialist breeding centres, particularly of Holstein cattle. Any opposition to 18th century "improvement" by the inarticulate and illiterate has not received comparable study, with William Cobbett being the only outspoken opponent. The imposition of similar Western concepts of "improvement" in cattle breeding, by vested interests, in late 20th century India aroused a storm of protest from the educated elite (Alvares 1985; George 1985), who articulated concerns that may have

been equally current in 18th century England but were wholly ignored. Scientific studies (Hall 2004) are now demonstrating the biological value of regional biodiversity in livestock breeds.

iv. Eating quality of bull beef

The eating quality of beef in relation to the classical and medieval doctrine of the humours is considered in detail in Chapter 5. Here, it should be noted that beef was considered to be cold and dry in humour, becoming progressively "drier" with the increasing age and/or the leanness of the animal, exacerbated in the entire male (Scully 1995, 48). Only peasants and those engaged in heavy labour were thought to have the digestive powers to cope with such "gross meat" (Redon et al. 1998, 110).

It can be seen that the pursuit of the "trophy head" may be in inverse proportion to the eating quality of the carcase. This could be part of the reason for the head and skin only body part representation for the Natufian gazelles and PPN ibex discussed above. It was certainly part of the rationale for bull blood sports and bull baiting, where the sweat engendered by the animal was considered to add a "warm, moist" aspect to the "cold, dry" meat, thereby neutralising it and making it fit for consumption. Conversely, modern opinion is that adrenaline and general stress results in the meat being tough.

This balance between the status of acquiring the trophy head, the comparatively short lifespan of the "best" males and the poor quality of meat from the senior adult male may be part of the original logic for sacrificing such animals and placing them outside the human food chain. This is seen particularly in the archaeological evidence for cattle sacrificed at Gallo-Roman shrines, summarised by Watson (2007, 166-172), which were predominantly males, roughly two adult bulls to every three oxen but twenty bulls to three cows, contrasting with the one bull to twenty cows in live herds, proposed above. Skulls appear to have been cleaned by decomposition for exhibition, eventually being deliberately positioned and buried in the sanctuary ditch.

As bulls greatly outnumber cows in such deposits and aged animals predominate, the interpretation is that the offering was based on the prestige of the animal, not the quality of the meat. Indeed, in one shrine old bulls were not destined for human feasting but the carcases were allowed to decompose in a pit for the purpose within the sanctuary.

In the Roman military zone of northern England, cattle bones are found in abundance on Roman forts but not on the contemporaneous, and earlier, indigenous sites, as soil conditions are hostile to the survival of bone. While cull cows fed the army, the evidence from contemporary Gaul indicates the calibre of rural sacrificial remains that may not have survived. It can be seen that if comparable sacrifices were part of cult practice in northern England, the mature stock bull would not be represented in the refuse from domestic food consumption and so be invisible in the archaeological record

v. Artistic Representations

In the Classical world, the bull was a potent symbol of masculinity in mythology and religious iconography. Examples include the myths of both the Minotaur and Europa and the bull, the attribute of Jupiter Dolichenos, the Suovetaurilia and the Mithraic Tauroctony. Whitlock (1977, 32-62) summarises the most famous images and their context. The degree of refinement of such sculptures varies throughout the provinces, suggesting that, in military contexts at least, some may have been carved locally and depict indigenous stock, such as the example from Bridgeness on the Antonine Wall (Henig 1984, 86-7). The continual drain of what were considered to be the "best" bulls for sacrificial offerings could have either impeded "improvement" in breeding, in the modern sense, or created a demand for animals with the desired attributes.

The sacrificial scenes of the suovetaurilia are of special interest. The victims are garlanded and unfettered and convey a sense of calm. The victim was supposed to consent freely to the sacrifice, indicated by lowering the head for slaughter. This was achieved in practice by placing salt on the ground for the beast to lick (Detienne & Vernant 1989). The Tauroctony (Henig 1984, 103) was the focal image of Mithraism, though exact details of the cult and its rituals have not survived (Henig 1984, 108). Mithras looks away from the bull even as he plunges in the dagger, killing the bull in the same manner as a modern matador, by slicing through the aorta (Hay 1976, 88), though Mithras approaches the target area from behind, whereas the matador faces his victim.

This method of killing may explain the complete cattle skulls with undamaged frontals found particularly in Romano-British structured deposits. For example, two cattle skulls were deposited prior to the laying of the wooden floor of one brine settling tank at Welsh Row, Nantwich (Archaeological Services 2007b, Gidney 2012). One skull was deposited with the neck still in articulation. Mounted heads (including

the neck) of notable bulls are part of the décor of the modern Spanish bull breeders *finca* (Hay 1976, 15-16). Bucrania are depicted as integral components of classical religious iconography, for example supporting swags on the *Ara Pacis Augustae*. Whether examples of prowess or sacrifice, or both, such numinous skulls could not enter the same disposal chain as mundane domestic food refuse and may therefore be under-represented in such assemblages.

In medieval art, bulls appear in Zodiacs as the star sign Taurus and in Bestiaries, where the iconography explicitly attributes both a good and evil significance to the bull (Barber 1999, 88-9), and among the marginalia of other religious works, most famously the Luttrell Psalter (Backhouse 2000, 34). The Luttrell Psalter bull is of interest as no cows or calves are depicted, only oxen. This bull may therefore not be a breeding animal but either awaiting castration to become a replacement ox or a draught animal in his own right, as noted above.

2.3 Data from the Modern Zanfara Dexter Herd

In the next section two Dexter skeletons will be examined as providing points of reference for differentiating the adult stock bull. A brief life history of these two animals is given here, to establish the background conditions in which they lived and to illustrate incidents that might have been anticipated to leave trauma on the bones. It should be emphasised that only the skeletons from two senior stud bulls used in the Zanfara herd could be collected. No bulls from other Dexter herds could be obtained as the herds offering elderly cows were generally using A. I. Mature bulls were uncommon and retained a cull value beyond the budget of the author.

Aiskew Juglans Nigra was purchased in 1989 as a proven 2 year old bull. At the time of acquisition, he was unusual for the breed as he was non-short. Juglans Nigra had been dehorned as a calf. Dalmuir Cyclone was purchased at 8 months old in 1990, as a weaned stirk (see Chapter 3) with the horns retained. Cyclone was blind as a result of an eye infection as an infant calf. The blindness was not seen as an infirmity by the author, as a bull detects cows in oestrus by scent and a bulling cow ready for service will find the bull. In fact deliberate blinding by the use of a bull blind (Ingram 1979, 6-9) on the stock bull was a management tool of the 19th and 20th centuries. Cyclone was short-legged.

Cyclone grew up with Juglans Nigra as the senior sire and, because of his blindness, did not challenge Juglans Nigra for supremacy when he was mature. Most of the time, the two bulls co-existed harmoniously when the cows were in calf, Plate 2:10. Major altercations did occur when Juglans Nigra returned home from hire and reasserted his dominant position. On one occasion, Cyclone was thrown bodily over a fence into the adjoining field. Such an experience might be expected to leave trauma on the bones. Juglans Nigra lost his dominant position as herd sire after a further bull, Weardale Didiscus, introduced to the herd as a weaned stirk, grew up to challenge Juglans Nigra. Didiscus was short-legged but had the advantage of relative youth being about 4 years old at the time of the challenge, some 7 years younger than Juglans Nigra. The ploy used by all the Zanfara herd bulls against a larger opponent of a broadside, rather than head to head, attack, to get the head under the barrel of the body and toss the opponent, succeeded against Juglans Nigra. At the time, this seemed a relatively minor altercation compared to some of the bull combats. Subsequently, it became apparent that this had been the defining moment when Juglans Nigra was ousted as Zanfara King Bull, as he had run away from Didiscus, the act of submission to a superior in the rank hierarchy. Thereafter, Juglans Nigra followed the classic behavioural pattern of a deposed dominant male ungulate, becoming solitary as far as practicable, and senile with loss of both libido and fertility. The damage appeared to have been psychological rather than physical. Juglans Nigra died peacefully while out on loan. No specific signs of sickness or ill health were observed by the hirer but Juglans Nigra had become lethargic, lost interest in cows and left no posthumous progeny. Cyclone died by mischance when on loan, through falling into a water catchment tank which he could not see, where he drowned.

Table 2: 1 gives an indication of the working lives of both Juglans Nigra and Cyclone in terms of their progeny recorded in the DCS Herd Books and the Zanfara herd diaries. Neither of these sources are complete records as many breeders fail to birth notify male calves destined for meat. The advantageous numbers of heifer to bull calves sired is therefore misleading. These records also fail to indicate the numbers of cows served that failed to conceive or the numbers of repeat services to achieve conception. Both bulls had a working life and overall harem size in excess of the modern Chillingham King bull (Bilton 1957, 140) and probably also in excess of the wild aurochs.

Despite their small stature, Dexter bulls appear to have testes of similar size to those of modern commercial bulls, suggesting a higher proportion of male breeding hormones to body weight and concomitant increase in libido. Scrotal circumference is quantified for all bulls standing for A.I. Table 2: 2 compares the recommended minimum sizes for a range of commercial beef breeds in North America to a sample of young Dexter bulls from South Africa and all the Dexter bulls available on A.I. in Australia. The latter include animals living in Europe and North America. The mean size for the mature Dexter bulls is comparable to the recommended minimum for the larger breeds.

Juglans Nigra regularly jumped fences to challenge the neighbouring farmer's Belgian Blue bull, running with commercial cows. Two points are pertinent here. Firstly, it appears not to be generally recognised that cattle can jump substantial obstacles, an activity, if repeated frequently, which could be envisaged as putting unnatural stress on joints, leading to skeletal modification. Secondly, the Dexter entire male, unlike the majority of ungulate males, does not appear to consider his relatively small size a disadvantage when initiating an act of aggression. Put simply, he is mentally as big as his testes, which, as demonstrated by Table 2:2, suggests that the Dexter perceives no size differential. Juglans Nigra was not an isolated example as a subsequent non-short senior sire, Hill Farm Thomas, followed the same behavioural patterns. Thomas challenged a Limousin bull, who accepted the challenge, unlike the Belgian Blues. This fight was broken up by human intervention before the combatants had reached the stage of submission by one party. Thomas took a severe beating but was undeterred, lived without outward appearance of injury and continued to sire calves and jump fences. Given the ferocity of the incident, Thomas must, at the very least, have fractured some ribs. However, he was the challenger, not the defending King Bull, and did not submit to the Limousin so did not follow the behavioural pattern seen for Juglans Nigra. Thomas was sent on the OTMS, at the age of 14 years 4 months, as a fit animal still capable of breeding, as it was no longer possible to legally retain the skeleton. Breeding bulls can therefore experience severe physical punishment with an outward appearance of nonchalance, but such incidents might be anticipated to be recorded in the skeleton by evidence of trauma and healing. The senior sire in the Zanfara herd in 2009 was Knotting Leo, born in 1994, and still working as a hire bull earlier in 2009, prior to his sudden death in October. Advanced

age is therefore not a barrier to reproductive success in comparison to loss of position in the dominance hierarchy.

Also of relevance to the topics of size and sexual maturity is the behaviour of even very junior bulls in the absence of a senior sire. Since most Zanfara bull calves are not castrated, even a bull calf suckling his dam will then take on the role of resident patriarch and patrol the fence lines diligently while "growling" at the commercial bull in the adjacent field. Such young bulls are easily controlled by the senior bull on his return. The presence of the senior bull simplifies management of the younger bulls, as he sets boundaries for acceptable behaviour, and control of the senior bull places the human herd-person at the top of the dominance hierarchy. By the time the younger bulls reach about two years old on this system, decisions have to be made about removing them from the herd to avoid a confrontation that demotes the senior bull from his dominant position. Similar decision making at about 2-3 years of age was noted in the historical sources, above.

Such behaviour patterns may help to explain the absence of evidence for cross-breeding between aurochs and domestic cattle in Britain, although the two co-existed during the Neolithic and Bronze Age. If the aurochs had a well defined rut, like modern red deer, then the human herders could keep the domestic herd away from the rutting grounds and away from the bachelor herd outside the rut. Domestic cows breeding aseasonally would be guarded and covered by the domestic bull. Despite the massive body size difference between domestic and aurochs bulls, it is obviously unknown whether this also applied to scrotal size. If the aurochs had a smaller scrotum in relation to body mass than the domestic bull, then a situation might be envisaged where the aurochs, like the Belgian Blue, may have submitted to the smaller domestic bull without a fight, outside the rut.

It is important for a stud bull to have sound feet. Both Juglans Nigra and Cyclone walked well, showed no signs of lameness when alive and did not require hoof trimming.

2.4 The Dexter Reference Skeletons

In the following discussion, the bones of Juglans Nigra, in particular, will be described in detail to act as a template for comparison, or back reference, in

subsequent chapters to obviate the necessity for such detailed description of the remaining Dexter skeletons.

The advanced age of these reference specimens is particularly valuable. Sten (2004, 67) found it very difficult to collect mandibles from male cattle older than two years from Swedish abattoirs. Sten also emphasises the importance of known age and documented life history in reference specimens. However, Sten was only examining age assessment based on teeth from mandibles collected at abattoirs, so there are no data on post-cranial elements. Sten was studying animals that were entering the human food chain, whereas none of the senior sires used in the Zanfara herd have entered the human food chain. This circumstance alone suggests hypotheses to explain the lack of readily recognisable evidence for adult bulls in archaeological assemblages derived from food refuse.

i. Skeletal ageing

The skeletons considered are: Juglans Nigra (16th March 1987 - 29th September 2000) and Cyclone (28th February 1990 - 15th June 1998). Both skeletons have all epiphyses fused and the permanent dentition erupted and in wear. This leaves only the wear stages of the teeth as a guide to the age at death. The system devised by Grant (1982, 91-108) is used to letter code the wear stages of the individual mandibular teeth from Premolar 3 to Molar 3, the TWS. The codes for Molars 1-3 are then given numerical scores, which are summed to give the MWS for the tooth row. The results in Table 2: 3 are discussed in Section 3.

Rates of tooth wear may be affected by diet, as well as age. The Zanfara herd bulls run outside all year on unimproved pasture, supplemented by hay in winter. Very rarely, turnips are fed in spring. The cattle also pick through their straw bedding and Juglans Nigra had been on a straw-based diet in the herd where he was bred. Both bulls spent much time out on hire, encountering a wide range of pastures and conserved forage.

ii. Osteology, Pathology and the Stock Bull

While Baker and Brothwell (1980) remains the standard text on archaeological animal bone pathology, much subsequent research, summarised by Johannsen (2005, 39-51), Groot (2005, 52-57), Fabiš (2005, 58-62) and Telldahl (2005, 63-67), has been aimed at identifying the remains of draught oxen in archaeological assemblages,

especially from pathological changes to the bones of the feet. Detailed consideration has been given to the nature of the stresses placed on the skeleton by using cattle for draught work, how the bones might be expected to react to, and compensate for, such stresses and how to distinguish pathologies caused by draught work from those associated with old age (Johannsen 2005, 40). The lack of a body of modern comparative material from animals of known history has been bewailed as a constant hindrance to interpretation (Johannsen 2005, 40 & 42). As a partial resolution to this problem, Johannsen (2005, 42-44) included data from aurochs. This was a laudable concept to provide a control sample for comparison with the domestic Neolithic archaeological finds. However, neither Johannsen, nor any of the researchers attempting to elucidate the presence of draught oxen on archaeological sites of any period, appears to have considered differentiating the draught ox from the adult non-breeding bull or the stock bull.

Broad interpretations of cattle keeping in the past presume that the majority of males born will either have been killed as young calves so the dams could be milked or, if raised, castrated for use as draught oxen. The possibility of adult sporting or sacrificial bulls is ignored as only a few males are expected to have been reared as entire males for breeding. Stock bulls, if put to work at about three years old and kept till about ten years old would have a similar working lifespan to a draught ox, see Chapter 6. Such a long working life as a sire might be anticipated to put abnormal strains on the skeleton of the active domestic bull. In the forelimb, this would result from the "pedal thump" dismounting from the cow and in the hindlimb and pelvis from mounting and serving the cow. The former would become more of a stress on the bones with the increasing age and weight of the bull. The latter would be more severe when attempting to cover a cow not yet on "standing heat", when the bull is attempting to run on his hindlegs, having mounted the cow. Received wisdom contends that a service is more likely to be successful in this situation. As noted in Table 2: 1, the unnatural reproductive demands placed on these two Dexter bulls could be expected to be reflected on the bones by morphological changes in response to stress on joints.

While it is acknowledged that two specimens is an extremely small sample, it is hoped that this contribution will go some way towards filling the void, identified by Thomas & Mainland (2005, 2), of research on specific conditions in modern domesticates and the lack of whole bodies available to zooarchaeologists compared to

their colleagues studying human palaeopathology (O'Connor 2008a, 166). Terms used for pathological changes are those defined by Baker and Brothwell (1980, 223-8), with "lipping" explicitly glossing osteophytosis. Besides conditions explicit to the bull skeletons, this section will also introduce topics to be considered throughout the herd in the subsequent chapters, particularly possible age and sex related changes.

O'Connor (2000, 119-122) reviewed the occurrence of non-metrical traits commonly encountered in archaeological assemblages. Two traits occur on cattle teeth, namely congenital absence of mandibular premolar 2 and of the hypoconulid on mandibular molar 3. O'Connor (2003, 184) suggests that high frequencies of such traits may indicate small populations with a high degree of genetic isolation, assuming the trait was present in the founder population. This project provides an opportunity to test this proposition against animals of known lineage.

Baker and Brothwell (1980, 109-114) drew attention to depressions in articular surfaces of archaeological cattle bones and defined three types, principally on phalanges but the occurrence was also noted on humerus, astragalus, scapula, radius and mandible. All three types are now subsumed within the definition of *osteochondritis* or *osteochondrosis dissecans* as cleft formation through articular cartilage, a common disorder of growth cartilage (Ytrehus *et al* 2007). For archaeological finds, both O'Connor (2008a) and Thomas and Johannsen (2011, 52) suggest the specific diagnosis of *osteochondritis dissecans* should be avoided in favour of the less specific term osteochondrosis (OC), indicating a manifestation of malformation in the cartilage of the joint surface.

Heredity is thought to be one of many factors involved in the aetiology of this disorder (Ytrehus *et al* 2007, 436-7). The chondrodysplasia of the short-legged Dexter might be anticipated to predispose towards expression of this joint surface malformation. The Dexter skeletons provide an opportunity to record the occurrence of OC both throughout individual skeletons and between skeletons of known family relationship, contributing to Thomas and Johannsen's (2011, 53) conclusion that studies of cattle with known clinical history are required to develop an understanding of the formation and prevalence of these depressions.

iii. Skull and Mandibles

Grigson's (1974, 1975, 1976, 1978) work on bovine craniology was by Grigson's (1974, 353) own admission of restricted applicability to archaeological

finds, which are rarely intact. However recent reference material is of value in its own right and the Dexters of this present study complement and extend the range of breeds represented in the museum collections studied by Grigson (1974, 354-357). Degerbøl and Fredskild's (1970) study of Danish aurochsen illustrates the crania in immense detail but not post-cranial elements. These two studies of the 1970's appear to be the end of the "trophy head" approach to archaeological material. Subsequent recording systems for archaeological finds have veered to the other extreme, with the Sheffield school of zooarchaeology recording only horn cores and mandibles and no other elements of the skull or of the rest of the axial skeleton (Pappa *et al* 2004, 32).

Among the non-measurable characters of the cranium observed by Grigson (1978, 143) is a change in bone surface from porous in juveniles, then becoming smoother and finally increasingly rough in old age. The latter attribute is apparent on both these bull crania, with this roughness spreading onto the frontal bones of Cyclone. Juglans Nigra has such a rough cranial surface that, on cleaning this specimen, a massive inflammation of the periosteum of the skull was considered as a contributory cause of death. However, Grigson's study shows that this is a normal attribute of old age and that examples occur among aurochs skulls (1978, 144, Fig. 10). Despite the fact that this is an age-related condition, the resemblance to periosteal inflammation warrants further consideration.

Schloeth's (1961) study of Camargue cattle illustrates and discusses several behavioural patterns that are also common to the Zanfara Dexter males. These are the ground horning, ground head and neck rubbing, head rubbing of tree trunks, shrubs and bushes (Schloeth 1961, 580-582; 581 Figs 7-8; 588 Figs 15-16; 589 Fig 17) and head to head horn contact between cattle (Schloeth 1961, 593, Fig 19). These behaviours are also exhibited by the Chillingham herd (Hall 1989). Though all cattle in the Camargue study group partook of this behaviour, even calves, it was particularly prevalent and prolonged among the males, and this has also been observed for the Chillingham cattle.

While a quantitative study has not been made of such behaviour among the Zanfara herd, qualitatively these are striking activity patterns. Noticeable differences in preferred behaviour have been observed between the adult bulls. Thomas was an inveterate head rubber against certain of the outbuildings on the holding, Plate 2:11a, a transference of tree trunk rubbing behaviour. In one field, three successive bulls have exhibited variations in preferential behaviour. Juglans Nigra was an exponent of

the ground head and neck rubbing and excavator of pawing ground, Plate 2:11b. Schloeth (1961, 582, Fig 9) illustrates a cross section of a pawing ground and rubbing area. This could be of interest for the archaeological interpretation of amorphous shallow features encountered on rural archaeological sites, as an alternative to the domestic fowl dust baths described by Dobney *et al* (2000, 91-3) and the depressions created by tethered horses (Baxter 2007). Zanfara Orlando was another bull who head-rubbed outbuildings. Plate 2:11c demonstrates the extensive reconstruction work required on one shed after Orlando spent a summer in this field. Zanfara Lawrence, son of Juglans Nigra and sire of Orlando, also spent much time in the same field but used the stay lines of two electricity poles for head and neck rubbing, necessitating erection of a protective fence, to which Lawrence transferred his head and neck rubbing activity, Plate 2:11d. What is of interest is that these three closely related animals exhibited such subtle differences in behaviour patterns, when at pasture in the same fields under broadly similar background stimuli. An understanding of behaviour patterns and rank hierarchy among breeding bulls may therefore be of value for the interpretation of this roughness on the skulls of aurochs bulls. Equally the absence of this roughness on domestic bull skulls has interesting connotations for the interpretation of past behaviour patterns in domestic cattle, the human management of the stock bull and his life expectancy. At the TAG 2007 conference, one speaker queried the relevance of the study of animal behaviour to zooarchaeology. This example shows that understanding behaviour patterns may be helpful for interpreting the aetiology and presence/absence of this skull roughening in archaeological collections.

These behaviour patterns were always far more obvious when two breeding bulls were at home, either both with a harem, or one bull with a harem and the other with younger male companions. Schloeth's (1961, 582) study showed that male Camargue cattle, in particular, would spend about 30 minutes a day engaged on the various head rubbing activities. It seems plausible that, over a lifetime, this constant irritation of the head could induce the roughness, seen firstly round the orbits then spreading to the frontal bones, zygomatic and temporal borders of the skulls of mature cattle, as a periosteal reaction. Weston (2008, 48-9) points out that the mechanisms of periosteal new bone production in humans can be complex but that anything that touches the periosteum can stimulate the initiation of bone formation. While, as noted above, the advanced stage of roughness of the skull occurs in aurochs specimens, the

author has yet to observe a striking domestic example among archaeological finds. This, of itself, strongly suggests that domestic bulls were not kept to an advanced age or in herd situations where the senior breeding male needed to constantly assert his hierarchical position against contenders by head-rubbing behaviours.

The internasal sutures of both Juglans Nigra and Cyclone are fused, which agrees with Grigson's (1976, 125) data that ossification occurs in all adult bulls, commencing at about five or six years of age and being complete between seven and ten years old.

Neither bull exhibits absence of either premolar 2 or the hypoconulid on molar 3. Table 2:3 shows that the mandibular teeth of Juglans Nigra are at advanced wear stages. Additionally, the dental arcade has become uneven on both maxillae and mandibles with periodontal disease, or gingival inflammation, and resorption of alveolar bone. Similar periodontitis has been observed in the majority of adult Chillingham cattle that have died of natural causes (Ingham 2002). Levitan's (1985) proposed methodology for recording such uneven dental arcades has never been adopted. These dental problems must have contributed to the inefficiency in chewing and cudding observed in Juglans Nigra's later years. The incisors of Juglans Nigra were seen to be worn down to small stumps in life, which would have reduced the efficacy of grazing a short sward. Advanced and uneven tooth wear together with gum infection may be seen as a major contributory cause of death. The lethargy observed for Juglans Nigra in old age may be also related to an inability to process sufficient fodder to provide the energy for activities beyond body maintenance. Morton Boyd and Jewell (1974, 367-8) observe that malnutrition is the primary cause of mortality for a range of wild ruminants and that low nutritive status is reflected in behaviour, with such animals becoming listless.

iv. Ribs and Vertebrae

Ribs and vertebrae are marginalised, or not recorded at all, by most zooarchaeological recording systems, including the "zone" method, devised by Rackham (1987a & unpubl.), used by the author. Ribs fragment into large numbers of undiagnostic shaft fragments, vertebrae have generally been chopped into small pieces. There are no widely used metrical data to be recorded. The opportunity will be taken to examine what information might be derived from this neglected part of the skeleton.

All the post-cranial elements of Juglans Nigra exhibit pronounced surface rugosity and ossification of ligaments and other soft tissue attachments, in striking contrast to archaeological finds of cattle bones. Like the cranial roughness, the first impression is possibly of pathological response, though the example of the cranial roughness suggests that such rugosity may fall within the normal range of variation, related to age. Such rugosity will therefore be taken as default on this skeleton and only specific instances will be described in further detail.

There are seven cervical (atlas, axis, VC 3-7), thirteen thoracic (VT), six lumbar (VL), five sacral (VS) and eighteen to twenty caudal (VD) vertebrae in the cattle skeleton (Hughes & Dransfield 1953, 43).

The bull's neck is proverbially strong and robust and this is reflected in the cervical vertebrae of Juglans Nigra, Tiny patches of eburnation were observed on the left side cranial and caudal facets of VC4. There is no evidence for any impairment of function of the cervical vertebrae, despite a lifetime expressing the normal behaviours of head rubbing and contests with other bulls.

Cyclone's bones display similar rugosity and ossification of soft tissue attachments but not to the advanced extent observed for Juglans Nigra, possibly since this animal was younger and subordinate. Additionally, Cyclone has depressions in the caudal articular surfaces of the atlas, though there are no corresponding marks on the cranial articular surface of the axis. However, the ventral border of the caudal articular surface of the atlas shows degeneration of the surface, with pitting, that is mirrored on the axis. There is minor lipping on the border of the caudal epiphysis of the centrum of the axis. VC5 has a depression on the right hand cranial facet, but there is no corresponding depression on VC4.

These large and robust cervical vertebrae reflect the size and power of the bull's neck, even in such comparatively small animals. The size of the neck is one of the most striking dimorphisms between the bull and the cow, Plates 2: 12a-b, and has also been noted for gazelle by Cope (1991). Unfortunately, the butchery required to sever the head and split the carcase usually results in fragmentation of the atlas and axis, the cervical vertebrae most commonly recorded by zooarchaeologists, to the extent that such dimorphism is unlikely to be recognised and certainly not metrically quantifiable, though Driesch (1976, 67-9) has defined measurements for the complete atlas and axis. Grigson (1982, 9) noted the potential of the atlas and axis for sexual dimorphism but was only aware of one author who had attempted to use such data.

The thoracic vertebrae of Juglans Nigra exhibit pronounced muscle and ligament attachments on the dorsal two thirds of the spines but less on the third embedded more deeply in muscle. The left first and second ribs have OC in the capitulum mirrored in the corresponding facet on VT 1-2. The left second rib has a tiny patch of eburnation on the capitulum, matched on the articulating facet of VT2. VT4 has an osteophyte below the caudal rib facet on the left side. Similar osteophytes are present on both left and right sides of VT5-6, being more pronounced on the left side. In VT7-8 osteophytes are present both above and below the caudal rib facets on both sides. In addition VT8 shows asymmetry of the caudal spine facets with the osteophyte from the rib facet spreading to the spine facet. The corresponding ribs show matching osteophytes round the capitulum. VT9 shows more pronounced osteophytes from the caudal rib to spine facets and minor osteophytes bordering the cranial rib facets. VT10 has osteophytes posterior to the cranial rib facets only. VT11 has only minor osteophytes round the rib facets and minor asymmetry of the caudal spine facets. Very fine pitting was observed throughout on the joint surfaces of the centra, but no lipping.

Cyclone shows comparable traits. The rugosity of the thoracic spines is confined more closely to the apices. Articular depressions in the facets articulating with the ribs are present on VT1 and VT8 but not on the corresponding ribs. There are no pronounced osteophytes round the articulations of the ribs and thoracic vertebrae, but lipping round the centra of VT3-7 is present, together with the very fine pitting of the articular surfaces of the centra.

The ribs of Juglans Nigra all have very rugose caudal borders. The distal halves of the lateral surfaces all have patches of long-established ossified soft tissue. While this may have originated as a reaction to the broadside assaults encountered by Juglans Nigra in his prime, an age related aetiology is suggested by comparable bone surfaces on the skeleton of an Exmoor pony, aged about 40 years, in the author's collection. The right hand *c.* 10th rib has a foramen in the caudal border for a blood vessel. This feature appears as a trait in archaeological collections, not worthy of comment as it does not normally occur on a fragment encompassing a "zone" for recording purposes. However, Holmes (1981, 150-152) described and illustrated a 16th century example from Coventry. As a veterinarian, Holmes believed this to be a pathological trait as he considered that there should not be a blood vessel present at this location and so postulated the presence of a large lesion, such as an abscess or

tumour. This study will ascertain whether or not this trait is a normal occurrence in the whole sample of Dexter cattle. The corresponding left rib of Juglans Nigra has only a notch in this position but this evidence for bilateral occurrence suggests normal variation, as no evidence for the presence of large lesions was encountered when defleshing the ribs. There was no obvious evidence for any healed fractures or breaks on any of the ribs. Cyclone has similar, but less pronounced, roughened caudal borders to the ribs. The surfaces of the ribs have minimal patches of the ossified soft tissue bone observed for Juglans Nigra. Cyclone suffered very few bull combats in life but was also a younger animal. The foramen in the caudal border is present in one matching pair of Cyclone's ribs, with notches in the equivalent position in the adjoining ribs.

The sternum is not an element that survives as a recognisable entity in the archaeological record. It is of interest in the case of these two Dexter bulls, as a lot of stress is placed on the sternum in the act of serving a cow. The sterna of both bulls show massive exostoses where the costal cartilages attaching the first and second ribs articulate. The entire surfaces of both sterna show ossification of soft tissue attachments, indicative of the active working life of both bulls.

Juglans Nigra displays a small area of lipping on the caudal border of the centrum of VL3, mirrored on the cranial border of the centrum on VL4. The lateral caudal borders of VL6 have small osteophytes, matched on the cranial margins of the sacrum. The sacrum is discussed further below, in conjunction with the ilia. VL1-6 of Cyclone all have small areas of lipping on the ventral borders of the centra. The caudal, but not the cranial, articulations of VL6 reflect the asymmetry of the sacrum, discussed below.

v. Forelimb

The scapulae of Juglans Nigra show ossification of the cartilage on the proximal border, though this is fragile and much has already broken off. The left humerus has substantial ossification over the rough prominence for the attachment of the infraspinatus tendon (Getty 1975, 749) but only minor ossification on the right humerus. The right humerus has a large exostosis on the distal lateral condyle but a negligible outgrowth on the left humerus. Both humeri have a semilunar depression on the lateral border of the distal condyle, Plate 2:16c. This is abnormal but may be congenital rather than pathological. It is not possible to get either of the distal humeri

and proximal radii of Juglans Nigra to articulate, due to expansion of the medial border of the semi-lunar facet of the ulna, which appears to be a reaction to the angle of the medial epicondyle bordering the olecranon fossa. Abnormal wear on this joint is indicated by eburnation of the lateral border of the semi-lunar facet of the right ulna and lateral facet of the proximal radius. The right radius has a more pronounced exostosis of the proximal lateral border than the left, mirroring the distal humerus. The left radius has a small patch of eburnation on the distal lateral facet.

The metacarpals of Juglans Nigra exhibit several of the pathological changes observed in the feet of modern draught oxen (Bartosiewicz *et al* 1997), including lipping of the proximal articular surface, exostosis development near the distal end and broadening of the distal medial condyle. While at first sight the scoring system for these anomalies devised by Bartosiewicz *et al* (1997, 37-41) appears straightforward, in practice it is less easy to apply this system to the specimen under consideration. The metacarpals of Juglans Nigra do, however, fall within the advanced stages of all these traits. Also of note is the presence of a small OC lesion on the proximal medial articular surface of the left metacarpal of both Dexter bulls.

Cyclone shows very extensive ossification of the cartilage on the proximal border of the scapulae with exostoses on the medial cranial and caudal borders not seen for Juglans Nigra. This ossified cartilage is fragile and already cracking away from the scapula so it is unlikely that it would survive in an archaeological context. The glenoid fossae of both scapulae exhibit a flattening of the lateral border, not seen for Juglans Nigra, and the joint surfaces are worn with exposure of the underlying cancellous bone and eburnation at the border with the unaffected joint surface. Degeneration of the joint surface is suggested by mirroring conditions on the proximal humeri with exposure of cancellous bone on the border of the left humeral head and small areas of eburnation on the surface of the humeral head. Similar, though less advanced, changes are apparent on the right humeral head. The proximal humerus is notorious for invisibility in the archaeological record due to vulnerability to a range of taphonomic factors, so these slight changes are unlikely to be paralleled among archaeological finds. Both humeri show expansion of the lateral border of the distal condyle, more pronounced on the left side.

vi. Hindlimb

The sacrum and ilia of Juglans Nigra have completely fused at the sacro-iliac joints. All the soft tissue attachments are extremely pronounced, more so on the left than the right, Plate 2:13a. Both acetabula are entirely free of eburnation, a condition associated with osteo-arthritis (OA) and age-related joint degeneration.

The sacrum of Cyclone has also fused to the ilia but in a more complicated fashion. The first sacral vertebra is asymmetric and lumbariform and has not fused at the centrum to the second sacral vertebra as it is out of alignment, Plate 2:13b. Had this been an archaeological find from a side of beef split sagitally, it is improbable that it would have been recognised that the two disparate sides of this specimen derived from one individual, particularly if they had been recovered from different contexts. Comparable conditions are observed in archaeological human skeletons (Barnes 1994, 59-71, 108-116) and are the result of asynchronous development of the foetus. Cyclone would appear to be exhibiting a related congenital trait. Agerholm *et al* (2001, 283) observe that "malformations of the axial skeleton are among the most commonly recorded congenital defects in calves".

Complex Vertebral Malformation (CVM) is a veterinary umbrella term for a suite of these deformities (Agerholm *et al* 2001, 283-9). Asymmetrical cattle vertebrae, though not as pronounced as Cyclone, have been discussed by Fabiš (2005, 58-62) in relation to possible draught exploitation but without considering the possibility of CVM.

There are two further scenarios which might appear plausible interpretations of the aetiology but need to be explicitly discounted. One is that this condition is an expression of the chondrodysplasia carried by Cyclone. Reported instances of CVM mostly occur in Holstein cattle (Agerholm *et al* 2001, 283-9), which are clearly not affected by chondrodysplasia. The second is that this may be a reflection of the "reverse" sexual dimorphism of the Dexter, whereby the short male is deliberately mated to the non-short female. Though such activity may cause stress to the pelvic girdle, it could not cause a congenital abnormality of embryonic development.

Sacro-iliac joint fusion is found in human skeletons. Dar and Hershkovitz (2006) consider the characteristic to be a reliable criterion for sexing male skeletons, particularly elderly individuals. Juglans Nigra and Cyclone suggest that this could be a diagnostic feature of the mature domestic stud bull too. Both Juglans Nigra and

Cyclone display the thick medial wall of the acetabulum, together with the short and broad pubis, characteristic of bulls (Grigson 1982, 8-10).

All the articular surfaces on both femora and tibiae of Juglans Nigra are normal, with no evidence for joint degeneration or OC. The metatarsals are also rugose but display neither the exostosis of the distal shaft nor the broadening of the medial condyle seen for the metacarpals. Both calcanea show substantial remodelling of the surface associated with ossification of the soft tissue attachments. Of particular note is the pronounced medial *sulcus tendini*, though this is not as extreme as the example illustrated by Telldahl (2005, 65, Fig. 4) and suggested as possible evidence for draught use of cattle. Dobney *et al*. (2007, 186) have drawn attention to this feature in the Anglo-Saxon cattle bones from Flixborough but suggest modern comparative material is needed before speculating on the aetiology. Like the foramina in the ribs, this is a trait that will be examined in all the Dexter reference skeletons as a contribution towards understanding the frequency and aetiology in this sample of the breed. Cyclone's right tibia exhibits a pronounced exostosis of the proximal lateral articular facet which is absent from the left tibia. The calcanea also exhibit exostosis development on the border of the medial *sulcus tendini*.

vii. Phalanges

Bartosiewicz *et al* (1997, 46-57) illustrate in detail the typology of exostoses observed in the phalanges of fore and hind feet of known draught oxen. When all four feet from one known individual are present, the separation of the digits is relatively straight forward. In an archaeological assemblage, the constraints of time and finance generally mean that such distinction is not usually attempted. Cupere *et al* (2000, 261) tacitly admit this by noting that only slight differences in their Pathological Index scores were observed between the first phalanges of fore and hind feet in the archaeological material of their study, so the results of all first phalanges were considered together. This is despite subtle differences in the typology of exostosis development in fore and hind limb, whereby Type 2 for the forelimb appears comparable to Type 3 in the hindlimb. Juglans Nigra seems to score Type 2 for lateral first phalanx and Type 3 for medial first phalanx, fore feet; Type 1-2 or Type 2 for the hind feet. However since Type 2 is dissimilar for fore and hind feet, it is questionable whether, in an archaeological assemblage, single examples of fore and hind first phalanges from Juglans Nigra would be recognised as deriving from the same

individual. Similarly, Cyclone shows wide variation in exostosis development both within and between the fore and hind feet. The more extreme Type 3-4 condition is seen only in the fore foot, Plate 2:14a-c.

The second phalanges of the forelimb of Juglans Nigra fall between Bartosiewicz *et al's* (1997, 51) Type 1 and 2 for exostosis development. Similarly, the second phalanges of the hindlimbs score Type 1. The second phalanges of Cyclone are comparable to those of Juglans Nigra in term of exostosis Type scores, Plate 2:15a.

The third phalanges of Juglans Nigra all appear to be at about Type 2 for exostoses, with only minor exostoses at the proximal end of the sort illustrated by Johannsen (2005, 41, Fig. 1) and Bartosiewicz *et al* (1997, 56) and used by Higham (Johannsen 2005, 40) as an indicator of draught exploitation. Cyclone is again broadly comparable to Juglans Nigra falling at Type 2 and with minor exostoses at the proximal end, Plate 2:15c.

This detailed consideration of the feet of the two bulls suggests that some of the criteria that are associated with known draught oxen may also occur in cattle that were not put to draught use. The wide variation in exostosis development present on phalanges within and between fore and hind limbs of the same animal raises doubts about the applicability and interpretation of this system to archaeological assemblages.

The presence and distribution of OC in the two bull skeletons is of interest since *Osteochondrosis dissecans* has been found in the joints of infertile breeding bulls and so considered to be a contributory cause of reproductive failure, even though no symptoms of lameness were apparent (Persson *et al* 2007). This may be of possible significance in the case of Juglans Nigra. Table 2: 4 illustrates the distribution of these lesions in the Dexter bull skeletons. The matching pairs of depressions within joints are of note. These were observed on articulating metapodials and phalanges by Thomas and Johannsen (2011, 51) and are recorded in the veterinary literature, together with bilaterally symmetrical occurrence (Ytrehus *et al* 2007, 432-4). The two Dexter bulls show the prevalence of OC lesions in the phalanges, Plates 2: 14b-c, 2: 15b, concurrent with the range of exostoses associated with draught oxen. This example suggests that the lifetime activity of the breeding bull may produce comparable osteological changes to those seen in the draught ox and that OC may be particularly linked to smaller cattle. The similarities between Juglans Nigra and

Cyclone suggest that sex or breed is more important in the expression of OC than the dwarfism carried by Cyclone alone.

Ward and Mulville's (2010) study of the manifestation of OC in archaeological cattle bones from Iron Age and Norse sites on South Uist observed a rise in frequency associated with the introduction of smaller cattle in the Norse period. The hypothesis is presented that an increase in such micro trauma was associated with an increase of arable, suggesting that these beasts were used for ploughing. However the frequency of OC decreased with a subsequent increase in the size of the cattle.

viii. Measurements

The measurements taken are those defined by Jones *et al* (1979), a subset mostly derived from von den Driesch (1976) with the exception of Length Trochlea (LT) for the distal humerus, equivalent to Height Trochlea (HT) defined by Legge and Rowley-Conwy (1988, 124). Though von den Driesch (1976) is the standard adopted by the zooarchaeological profession, a major disadvantage is the absence of explanation of how to analyse the data or the meaning of the data. O'Connor (2003, 172) points out that many of Driesch's measurements are either alternatives and/or highly correlated, leading to the collection of redundant data. Since the highly fragmented nature of the majority of archaeological assemblages precludes the taking of the majority of the measurements defined by Driesch, this author has routinely recorded only a very restricted suite of measurements from those deemed by Jones *et al* (1979) as being most pertinent to English archaeological sites. These have been principally the basal diameters of horncores, the distal trochlea of the humerus, the distal articulation of the tibia, the length and distal condyle breadth of metapodials. The attributes in common to this selection are their survival even in less than ideal preservational conditions, because of their robust nature, together with relatively enhanced recognition and recovery by hand excavation. This sample of elements includes an early fusing bone, the distal humerus, which should give information on a broad spectrum of the slaughter population irrespective of age and sex. The distal tibia has been preferred to the astragalus, as giving information on a more restricted suite of the cull population that has attained this developmental stage. Maltby (1979, 35) notes that the tibia shows less sexual dimorphism than, for example, the metacarpal and therefore is preferable for giving an overview of chronological trends in the size of cattle. The metapodials are frequently the only limb bones recovered intact for

estimates of withers heights, besides possible information on sexual dimorphism and draught animals from the distal articulation. Since an aim of this study is to generate data from the Dexters comparable with archaeological finds, metrical analysis of the Dexters follows the same criteria. Since two bulls is a small sample for discussion, these metrical data are considered in conjunction with the Chillinghams in Section 3, below.

2.5. Archaeological and Recent Case Studies

A selection of other skeletal remains of bulls will now be considered, to put the data from the Dexters, particularly the metrical data, in the context of other animals with divergent life histories. Given the widespread lack of recognition of adult bulls in archaeological assemblages, the known sex individuals include an example of an aurochs, 20th century feral Chillingham bulls, Comet as the zenith of early 19th century improved Shorthorns and an introduction to a recent reference collection in Germany. These are followed by a consideration of morphological change in the acetabulum, which is proposed as diagnostic of the senior bull.

Case Study 1: Hawick aurochs and Heck cattle

Little work appears to have been done on non-metrical traits on aurochs bones or on their overall morphology compared to domestic specimens. Likewise, no osteological studies appear to have been made of the foundation breeds used to create the Heck cattle, nor to compare the bones of the Heck cattle with their progenitor breeds and aurochs for attributes other than absolute size.

Wijngaarden-Bakker obtained the skeleton of a Heck bull in 1987, concluding only that Heck cattle are smaller than aurochsen. The metrical data from this Heck bull (Wijngaarden-Bakker 1997, 195-8) produced estimated shoulder heights ranging from 132-149 cm, using the multiplication factors of Matolcsi (Driesch & Boessneck 1974, 336) in general use by zooarchaeologists (O'Connor 2003, 178). The widest variation was seen in the bones of the forelimb, with an estimated height of 132 cm from the metacarpal and 149 cm from the humerus. It was observed that the different estimates for shoulder height follow a pattern, whereby the more proximal skeletal elements indicate a greater height than the more distal elements (Wijngaarden-Bakker 1997, 197). Such proportional differences in the estimates of height obtained from

different bones of the same limbs of individual aurochs bulls and the Heck bull suggest that factors for estimating the height of domestic cattle may not be applicable to the aurochs. The massive build of the aurochs appears to be concentrated in the size of the humerus. Wijngaarden-Bakker (1997, 197) suggested this may be a response to the size and weight of the horns. This seems only part of the explanation as Hall (2004, 10-11) notes that the power of the forequarters in wild ungulates is related to display and fighting and illustrates how selection under domestication has altered the silhouette of domestic animals in favour of a level back and pronounced hindquarter, instead of the powerful head and forequarter of the wild ancestor. Hall (2004, 23) also illustrates a modern African breed with massive horns but without exceptional development of the forequarter.

The Durham Department of Archaeology collection contains part of an aurochs bull skeleton found near Hawick, Roxburghshire *circa* 1980. This is incomplete with parts of the skull and one mandible, most of the ribs and vertebrae, one scapula and humerus, parts of the pelvis and half of one metatarsal. A few bones also appear to derive from a second aurochs, possibly female. These were adults as the epiphyses are fused and the permanent dentition is in wear. The aurochs, obviously, had no supplementary winter feed but was living in a different epoch in terms of climate and vegetational productivity. How comparable to the modern animals the tooth wear of this animal is in terms of diet and calendar age is unknown, though the MWS for this aurochs in Table 2: 3 is comparable with the reference bulls.

Despite their small size, the Dexter humeri reflect Degerbøl and Fredskild's (1970, 106) description of old aurochs bull humeri, as being large, broad and thick-walled. In this respect, the rugose soft tissue attachments observed on Juglans Nigra are more comparable with the aurochs than the Chillingham, below. The detail of the surface modelling of the distal shaft of Juglans Nigra and the Hawick aurochs is strikingly similar, Plate 2:16a, and is developing on Cyclone but absent from the Chillingham, Plate 2:16c. The massive build of the scapula and humerus in the aurochs and the Dexter, but not the Chillingham, Plates 2:16 b-c, therefore suggests a substantial difference in conformation. The robust bones with massive muscle attachments suggest powerfully built forequarters, though this was not an extreme feature of Juglans Nigra in life, Plate 2: 6.

Case Study 2: Chillingham Bulls

Two Chillingham male skeletons are used for comparative reference in the Durham Department of Archaeology. One is the bull referred to by Grigson (1974, 356) at Durham University, having been collected by Professor Cragg, who excavated, in 1951-2, the bodies of the Chillingham cattle that had died in the severe winter of 1946-7. The morphology of the pelvis is clearly male and no Chillinghams were castrated in the 20th century. The other specimen was a natural mortality, collected from Chillingham park *circa* 1980. Discussion centres on this specimen, following the description of the Dexters.

The feral herd of Chillinghams suggests that in a wild population only a few senior males would have mated with the cows. The energy expended in defending and serving a harem of cows means a fairly rapid turn over of stud bulls, with the breeding life of a Chillingham King Bull probably being two or three years (Hall & Hall 1988, 482), without human intervention in the herd structure. The recent Chillingham bull skeleton therefore derives from an animal that may not have achieved breeding rights, or if he had worked had only covered relatively few cows over, perhaps, a couple of years.

The age at death of neither Chillingham bull is known but all the epiphyses are fused, though the fusion lines are still visible on the cervical and thoracic vertebrae of the c. 1980 Chillingham. In both, the permanent dentition is erupted and in full attrition. The Chillingham cattle have parkland grazing supplemented by hay in winter. Table 2: 3 indicates that the MWS for the Chillinghams are comparable to Cyclone, aged eight, though the differences in TWS may reflect the feed ingested rather than calendar age. Nevertheless, an age of about eight years for the Chillingham bulls would accord with Whitehead's (1953, 48) statement that steers and old bulls were generally shot at six to eight years old in the 19th century. This practice may have arisen to pre-empt natural mortality.

On the skull, the roughness observed on the Dexters and aurochs is developing round the orbits. There is pronounced malocclusion of the third molars with a "hook" on the posterior cusp of upper molar 3 causing excessive wear on the third cusp of lower molar 3 and erosion of the bone on the dorsal surface of the mandible to the rear of molar 3. Ingham (2002, 171-2, Figs 5-6) describes several occurrences of this

condition, which appears to be a contributory cause of death, among subsequent fatalities of Chillingham cattle.

There is a large patch of eburnation on the left side caudal articular surface of the atlas, with a corresponding area of eburnation on the articulating surface of the axis. The lateral borders of the axis give the bone a squared shape, compared to the noticeably curved borders in both the Dexters, Plate 2:17. VC3 has major pitting of the cranial epiphysial surface, which is also present but less severe on VC4. Pitting is also present on the articular facets for the ribs on VT1-6. The spines of the thoracic vertebrae, the ribs and the transverse processes of VL show far less pronounced rugosity than the Dexter bulls. The Chillingham would have had far more opportunity for bull to bull peer group social interactions than the Dexters, suggested by one left side rib which has a visible break in the distal third of the shaft, still in the process of healing at the time of death. The right hand first rib has eburnation on the capitulum, also present on the articulating surface of VT1.

The bones of the Chillingham contrast visually with the Dexters. Though the scapula is of similar overall length to that of Cyclone, it is very much more gracile Plate 2:16b. Noddle (1989, 182) observed that the scapula of the aurochs has less proximal flare and a proportionally longer blade than modern cattle, though without remarking on which modern cattle breeds or types this observation was based. In this feature, the Chillingham might appear more comparable to the aurochs. However the gracility of the Chillingham contrasts markedly with the Hawick aurochs. Degerbøl and Fredskild (1970, 105) comment that the scapulae of the older aurochs bulls have strongly marked muscular attachments, as seen for the Dexter scapulae. The Chillingham humerus is of comparable length to that of Juglans Nigra. The outstanding difference is in the distal lateral condyle, which is normal in the Chillingham but distorted in both the Dexters, Plate 2: 16c. The Chillingham humerus is comparable in size and morphology with archaeological finds. The Dexter bones are very much more robust and heavy, as shown by the humerus weights of 755g for Juglans Nigra, 535g for Cyclone and 506g for the Chillingham.

The radius, ulna and metacarpal of the Chillingham are more gracile than those of Juglans Nigra, Plate 2: 18, though of similar length. The metacarpal lacks the exostoses on the distal shaft seen on the Dexters, Plate 2:19. The sacrum and pelvis of the Chillingham remain separate entities, unlike the Dexters. The hindlimb bones of the Chillingham are again more gracile than those of the Dexters.

While visual inspection has highlighted the difference between the robust Dexters and the gracile Chillingham, measurements quantify this impression, Table 2: 5a. Though the metapodials of Juglans Nigra and the Chillingham are comparable in length, the humeri and femora of the Chillingham are shorter than the Dexter whereas the tibiae are longer. So, although the two animals were of similar height, circa 1.10m, the proportions of the bones differ. The robustness of Juglans Nigra is demonstrated by the graphs plotting the dimensions of distal humerus and tibia, Figures 2:2a-b.

The Dexter and Chillingham skeletons provide an opportunity to test Matolcsi's factors against bones from animals of known general stature. Table 2:5b shows the results for the humerus, femur and tibia. It is immediately apparent that Matolcsi's factor for the humerus is seriously flawed as, in all cases, the live animals were far shorter. The discrepancy is particularly dramatic for Cyclone, who was less than 1m tall. The femur suggests a lower hip height than shoulder height, though both Dexters had very level top lines. The tibia gives heights that are good approximations for Juglans Nigra and the Chillingham but too tall for Cyclone. The Dexter and Chillingham results confirm the pattern, noted above by Wijngaarden-Bakker, of Matolcsi's factors producing higher height estimates from proximal skeletal elements. This strongly suggests that these factors are not reliable for estimating height from the humerus and femur in particular, even for modern breeds. Since the aurochs humerus, such as the Hawick example, survives well, it is possible that the height of these extinct cattle, as estimated from the humerus, may be exaggerated.

Since the more distal skeletal elements appear to provide more accurate estimates of height, the metapodials might give a more reliable impression of stature. Driesch & Boessneck (1974, 336) provide factors calculated by Boessneck, Zalkin, Fock and Matolcsi. Separate factors are provided for cows and steers in this table, but not for bulls. However, Zalkin (1960, 126) recommends using the average of the cow and steer factors when the sex of the animal is not known. These average factors provided accurate results when tested on the metapodials of Dexter reference skeletons from known height cattle. Table 2:5c shows the results of averaging the metapodial factors of all four authorities and applying them to the three modern bulls. Only Boessneck's factors err on the side of too tall. Zalkin, Fock and Matolcsi all produce broadly comparable results of the correct order of magnitude. The variation seen is similar to the error encountered when trying to measure a live animal on grass

in differing stages of body condition or coat growth. The factors given for entire male metapodials (Driesch & Boessneck 1974, 338) were used by Wijngaarden-Bakker (1997, 195-6) to calculate the height of the Heck bull. The comparison of the Dexters and Chillingham using these factors are shown in Table 2:5d. The results are broadly comparable to those obtained from the average factors of the other authorities, though erring a little towards exaggerating the height. These results are reassuring that estimates of the height of archaeological cattle derived from metapodials, using the average of the factors given by Zalkin, may give a reliable impression of stature.

It can be appreciated that estimates of withers heights may be no more accurate than estimates of age at death from tooth eruption and wear stages or epiphysial fusion sequences, discussed in Chapter 3. However O'Connor (2003, 178) suggests it is acceptable to use such estimated heights for the interpretation of data to a general audience, though seemingly not to apply equally broad ageing data. While in both instances the actual height or age may be flawed, using the same parameters across archaeological assemblages allows for comparison of relative, not absolute, variation in either stature or cull pattern. Size is also relative in the eye of the beholder. Juglans Nigra was criticised by one eminent Dexter judge and breeder as being "far too large" for the breed, whereas O'Connor (2003, 178) suggests a mean height of 1.13m indicates "just how small" archaeological cattle were.

Case Study 3: Comet

Comet was a light roan Shorthorn, Plate 2: 20, bred by Charles Colling and born in 1804. Comet's pedigree, Figure 2: 1, shows the degree of inbreeding practised by the Colling brothers and remains a standard text book example of this practice (Wright 1978). Comet's other principal claim to fame is the price he realised at the Colling's dispersal sale in 1810, when a syndicate of four men paid £1000 for the six year old bull, the first time this price had been realised for a single stud bull. Comet had begotten numerous progeny before the sale and the four members of the syndicate agreed to send annually 12 cows each to be served by Comet (Allen 1872, 75). After gradually sinking, "his body breaking out into sores" (Allen 1872, 75), Comet died in 1815, aged 11 years. A tree was planted on Comet's grave, which was removed in 1865, when the bones of Comet were retrieved (Proud & Butler 1985, 16 -18). One rib is currently in the possession of the Shorthorn Society. Other bones may also have been taken as souvenirs as only a very partial skeleton still survives in the archive of

Sunderland museum. Comet is therefore a very important specimen, bridging the historical records of the improved Durham Shorthorns with the physical archaeological evidence of the large and improved cattle bones found in later 18th - 19th century deposits, discussed in Chapter 6, some of which may actually derive from animals related to Comet. Despite this, the extant skeleton has been sadly neglected by the zooarchaeological community interested in skeletal evidence for improvement as a result of deliberate breeding policy.

The cranium of the skull survives and the surface roughness previously described is present on the frontals. The horns appear to have been removed at death as a cup made from a horn of Comet is in the collection of the Museum of English Rural Life (Spargo 1988, 43). In Table 2: 3 Comet, aged 11, is only one MWS stage beyond Cyclone, aged 8, and comparable with the more recent Chillingham. Comet would certainly have received supplementary feed to maintain his massive size but this would not appear to have increased the rate of attrition on the teeth. While the maxillae of Comet are no longer extant, the uneven wear on the right hand mandibular molar 3, Plate 2: 21, indicates that the occluding maxillary molar 3 was "hooked", like that of the Chillingham above.

The two surviving cervical vertebrae of Comet are commensurate with the robust size of the Shorthorn but exhibit neither the ossification of soft tissue attachments nor the minor arthropathies observed for the smaller breeds. The single surviving thoracic vertebra of Comet has pronounced osteophytes on the left hand caudal and minor expansion on the cranial margins of the centrum, together with lipping ventral to the caudal rib facet. Eleven of Comet's ribs survive, of which three have pronounced lipping of the ventral articular facet. There is very slight beading on the caudal margins but this is minimal compared to the Dexters. None of the rugosity and ossified soft tissue attachments described for the Dexters was apparent. The two remaining lumbar vertebrae of Comet exhibit lipping round the margins of the centra, pronounced on the right hand sides, together with expansion of the caudal facet of the neural arch on one.

The left scapula of Comet survives. In life, this shoulder was described as "slightly shrunk in, apparently diseased, which may have arisen from a violent sprain that he received when a calf" (Allen 1872, 74). This subluxation is apparent in the ossification round the joint capsule (Baker & Brothwell 1980, 126) and the eburnation and pitting within the glenoid fossa, Plates 2: 22a-c. It is noteworthy that this gross

pathology did not impact on the financial value of the animal, his ability to sire calves or his longevity, which has interesting implications for the interpretation of pathology in archaeological specimens.

The right humerus of Comet survives and there is no indication of pitting and eburnation on the proximal joint surface to suggest that the pathology observed on the left scapula was bilateral. The weight of this recent bone, 2330g, is comparable to that of the Hawick aurochs, 2099g (damaged, incomplete). The bone is massive and rugose, with the lipping of the attachment for the infraspinatus tendon seen for Juglans Nigra but also extension and fusion of the lateral and medial tuberosities Plate 2: 23a. The articulating radius and ulna are commensurately robust but show no age-related degeneration. The humerus of Comet gives an estimated height of 1.37m. Although this bone appears massive, it falls far short of the estimated height of 1.79m for the Hawick aurochs humerus. The discrepancy is less marked in the size of the distal trochlea in Figure 2: 2c, where the aurochs and Comet form a contrasting cluster to the Dexters and Chillingham. This supports the hypothesis proposed in Section 1, that removing active selection for diminution allows domestic cattle to revert towards the aurochs size range.

The left and right metacarpals of Comet survive. Neither exhibits either the expansion of the distal medial condyle or the exostosis on the distal anterior shaft seen for Juglans Nigra. Given the tremendous size and bulk of Comet, the degeneration of his left shoulder and his comparatively advanced age, this is unexpected. It suggests that predisposition for these conditions may be related to genotype rather than phenotype. There is a surprising discrepancy between the lengths of the two bones, such that the measurements were double checked to exclude operator error. The left side indicates a height of 1.41m and the right side a height of 1.36m, using the average factor of Zalkin. The estimate from the right metacarpal accords surprisingly well with the estimate of 1.37m from the right humerus. Matolcsi calculated his factors from extant European cattle. The early Shorthorns indubitably contained much Dutch breeding. This may explain why Matolcsi's factors give a satisfactory result for the "improved" Comet but not the indigenous British breeds nor the feral Heck cattle, which contain Highland cattle breeding. Johnstone (1999, 50) highlighted the problem of minor errors in taking Greatest Length measurements being compounded in subsequent estimates of withers height. However, the example of Comet shows that

even the seemingly reliable estimates of height from metapodials may mask bilateral asymmetry in bone length in individual animals.

The left femur and tibia of Comet survive. The femur is particularly rugose, exhibiting more extreme ossification of soft tissue attachments than that observed for the Dexters. Comet has one OC depression on the patellar groove of the distal femur.

Case Study 5: The Julius Kühn Museum reference collection, Halle, Germany

The paucity of British reference collections of known age and breed cattle skeletons has been highlighted by Jones and Sadler (2012, 12), who based their study of cattle age at death on the post 1863 collection at Halle. This comprises 3 bulls and 38 cows aged over 4 years at death, a higher proportion of bulls to cows than the 1: 20 proposed above. Data from the females in the Halle collection will be discussed in Chapter 5.

Mandibles from the three adult stock bulls of known age are extant (Jones and Sadler 2012, 18) and the MWS data are presented in Table 2: 3 in comparison with the other bulls discussed in this chapter. H820, aged 6 years, is at a comparable stage to the left mandible of the c. 1980 Chillingham, suggestive of the proposed 6-8 year lifespan for Chillingham males. H734, in his seventh year, is one MWS stage less than Cyclone, aged 8, and tantalisingly at similar wear stages to the extant teeth of the aurochs. H1083, in excess of 13 years old, accords in MWS with Juglans Nigra, aged 13 years 6 months. It can be seen that despite the differences in breed, feeding regime and TWS, the overall MWS does provide a relative sequence for the bulls that reflects the known sequence of calendar ages.

Case Study 6: Morphology of acetabula from adult bulls

Occasional archaeological finds are made of cattle acetabula which appear to be unusually deep. O'Connor (2008a, 173) illustrates an Iron Age example from Danebury, remarking on the marginal exostosis development which has retained the notch at the lateral end of the ilio-pubic suture as an elongated foramen within the acetabular wall. Plate 2: 24a shows a medieval example of this trait from Ripon, Yorkshire (Archaeological Services 2011). The morphology appears comparable to that seen for the two Dexter bulls in Plates 2:13a and b, with thickening of the ilial-pubic margin, pierced by a foramen. Comparison of the other bull acetabula in Plate 2: 24 a-f suggests an age-related progression in the development of this feature. The

more recent Chillingham bull displays a pronounced notch on the acetabular border between the pubic and ilial facets. An examination of the younger male cattle pelves, in chapters 3 and 6, suggests that this is characteristic of the younger male. The more historic Chillingham bull shows a clear bridge of this notch, joining the ilial and pubic margins and producing a foramen. Both Cyclone and the Hawick aurochs show substantial bridging of this notch, with a small crease like foramen, while Juglans Nigra displays a more rounded foramen. The archaeological specimens would appear to fit at the end of this progression, suggesting that it is in fact normal morphology for the aged stock bull, *contra* O'Connor (2008a, 173) who considered that such modification of the acetabulum would compromise sex determination based on acetabular morphology.

2.6 Discussion

The breeding bull is relatively invisible archaeologically, in part because little attention has been paid to the identification of entire males in archaeological assemblages, compared to the widespread endeavours to identify skeletal parameters that define the draught ox. However, this chapter has demonstrated some of the inherent problems in separating fragmented archaeological bones of entire and castrate males. Firstly, the historical sources suggest that a greater proportion of males may have been reared to young adults, aged 2-3 years, before decisions were made on selection for breeding stock, castration for oxen and culling for beef. At this age, earlier fusing elements, for example the distal humerus, will have fused, potentially obscuring separation of metrical data into entire and castrate male groups. Secondly, many of the morphological attributes on the Dexter bull skeletons are subsumed within those proposed as diagnostic of the castrate male. The aetiology may reflect a variety of causes producing similar skeletal changes, highlighting the need for differential diagnosis in interpretation.

Standard interpretations of changes in the size of cattle tacitly assume that recent concepts of the commoditisation of beef as a product distinct from the live animal (Rimas & Fraser 2009) were applicable in the past. This approach was queried and evidence propounded for alternative selection processes for both breeding and beefing bulls. Pragmatic response to environmental determinism, following Bergmann's Rule, was considered from the proxy of increase in body size in black

rats contemporaneous with increase in the size of cattle during the 16th century "Little Ice Age". Conversely, the impact of a "trophy head" strategy was seen as potentially reducing the body size of active breeding males, with a knock-on effect on the whole population. The "Ungulate Paradox" and the natural hierarchical combat between bulls to establish breeding rights were seen as underlying the temporal and spatial distribution of bull sports and the supply of sacrificial animals. Selection pressures on breeding stock to produce sporting bulls run contrary to expectations of "improvement" in terms of an increase in cattle size to provide bigger carcases for urban markets. Increased aggression in smaller bulls may be linked to higher testosterone levels and scrotal size relative to body size was found to be greater in the Dexter than larger modern breeds. Rather than beef being a primary aim of the cattle keeper, much bull beef may have been either a by-product of communal spectacles or a pragmatic cashing in of the "best" animals for sacrifice, pre-empting the natural early death of the fittest and most fertile bulls predicated by the "Ungulate Paradox". The example of Juglans Nigra demonstrated that the deposition of the herd "King Bull" would be the best time to beef the animal. Hindsight demonstrated that it was an error to have retained Juglans Nigra, a failure to appreciate the "Ungulate Paradox" in action, and the short time space between the prime of the animal and senility. This has implications for correlating calendar age with, for example, tooth wear stages.

The circumstances of death of the Dexter and Chillingham bulls and Comet suggest that a proportion of senior stud bulls may have gone down as fallen stock without entering the beef supply to the settlements which produce the majority of archaeological finds. A scenario of fallen stock suggests that entire males might be more readily identified on rural sites. Similarly, evidence was presented for dedication of such mature males at Gallo-Roman shrines, placing meat not considered desirable for human consumption outside the human food chain. Both trajectories would reduce the visibility of adult male cattle in assemblages derived from domestic consumption.

Detailed descriptions of the two Dexter bulls have been given as modern reference skeletons of adult bulls from unimproved traditional breeds, apart from the Chillingham herd, are rare. Conversely, Comet is unique historical and physical evidence for the improved cattle of the late 18th-19th centuries. Despite the size difference, evidence of the descent from the aurochs is still visible in the skeletons of these Dexter bulls, in terms of the progressive roughening of the skull and the surface modelling of the humerus shaft. Comet demonstrates reversion towards the aurochs

size range. To such extent, the Heck brothers' original contention that domestic cattle retain latent characters of the aurochs may be valid. It has been shown that the axial skeleton, largely ignored by zooarchaeologists, can provide information on congenital traits not present elsewhere in the skeleton. While the non-short Dexter and the Chillingham are of broadly comparable height, the difference in build apparent in the live animals is also reflected in the bones. Not only are the Chillingham bones more gracile than the Dexter but there are also differences in the proportions of individual limb bones contributing to the overall height. It was shown that the humerus gives least accurate estimates compared to known height while the metapodials were consistently more reliable. Estimates of height and carcase weight from dry bones may be flawed without taking such matters into consideration.

Chapter 3 will now consider the progeny of the bull, the criteria for rearing calves, the growing young stock and the watershed of entering the adult herd.

Chapter 3: The Calf and other young stock; stirks, stots and heifers

The calf is the second member of the herd to be considered, as the decisions made over which calves to rear dictate the composition of the adult herd. This chapter also encompasses discussion of young, growing stock, prior to entering the adult herd as either breeding or working animals.

In the 20th century, the traditional husbandry definition of a calf was an animal aged up to 6 months old (Morley 1950, 113). This is an immediate instance where zooarchaeological nomenclature, based on the ages of epiphysial fusion, fails to provide a clearly recognisable skeletal developmental stage to equate with a growth and management stage of the live animal, as all epiphyses are still unfused under six months of age. Separation of such young animals into a developmental sequence depends on recovery of the mandible, to establish tooth wear and eruption stages, and length of the limb bones. The fragile nature of bones from such young animals generally means that too few intact archaeological specimens are recovered for any meaningful analysis of metrical data from any one site, though Green Shiel on Lindisfarne (Scott 2000) is an outstanding exception. Two categories of bones from calves aged less than 6 months may be expected in the archaeological record. Firstly, perinatal mortalities, which may be indistinguishable from "bobby veal" calves slaughtered at a few days old for potted veal. This practice was associated with high yielding, extreme dairy conformation breeds, into the mid-20th century (Morley 1950, 155). Secondly, calves reared on whole milk for 8 to 10 weeks then slaughtered as white veal (Morley 1950, 155).

The presence of bones from such young calves on archaeological sites was taken by Legge (1981, 1992), to indicate a dairy-based cattle herding strategy. An interpretation which has subsequently become enshrined as a standard zooarchaeological approach to the interpretation of calf bones, further defined by O'Connor (2000, 89) as: "certain assumptions are probably quite robust, such as that a herd or flock kept primarily for milking will generate a surplus of young males which are neither needed for breeding nor useful for milking". This assumption will be challenged on the grounds that it fails to consider the need to balance the rearing of

replacements for the dairy with replacements for the yoke. The slaughter of infant calves is not in dispute, merely the evidence and rationale for the sex ratio.

The end of calfhood is generally synonymous with weaning, in the sense of cessation of milk feeding rather than merely removal from sucking the dam. From 6 months old, weaned cattle can be known as stirks or stores until they become either productive heifers or fat stock (Morley 1950, 115). Other regional variations in terminology include quey and stot in northern England and Scotland for female and male young stock. The common denominator for such terms appears to be the age cohort, older than calf but younger than adult. Harting (1880, 234) thought quey was a corruption of twynter, or two winters, the term for a two year old heifer. However, the OED definition of quey, and all variant spellings, is merely the Old Norse for heifer. A quey calf, for example, glosses heifer calf. Stot is an Old English word for a young bull or ox/steer. One definition specifies "especially of three winters", the OED gives examples of usage to mean a two year old bullock and the expression "twinter stot" to mean an ox of two winters. These examples suggest considerable local variation in meaning from merely female or male to animals specifically of a year cohort. It would appear that the exact calendar age of young stock was not the important consideration compared to the number of times the animal had been wintered. This is clear in the Welsh laws, Table 3:1, discussed below. These traditional age cohorts contrast with zooarchaeological nomenclature, such as juvenile and subadult. The data from the Dexter reference specimens will be considered in age cohorts to examine the correspondence between husbandry and analytical groupings. Neutral terms, such as juvenile, have arisen to avoid the confusion caused, for example, by zooarchaeologists using the term "calf" to describe an animal about 18 months old at death. However, terms such as juvenile or sub-adult can also fail to convey the actual age cohort and nature of the live animal.

Following on from the rut, discussed in Chapter 2, seasonality of breeding and survivability of calves born will be considered here. The view expounded by O'Connor (2008b, 90) that it is "highly unlikely" that 15th century cattle were breeding year-round will be challenged, both from the evidence of the historical sources and modern data on calf survivability, particularly from unimproved and feral herds.

Published data on Dexter calf birth weights will be examined to establish both the mean birth weight and range of variation. This impinges on calf survivability and

the possible effect on the future population by the subsequent selection of either extremely large or small calves to enter the breeding pool. The young animals in the reference collection are of particular interest as providing a new dataset of epiphysial fusion events from animals of known life history for comparison with traditional husbandry groupings of younger animals and ageing schemes used to interpret archaeological data. Since dwarfism is not an aspect actively sought in archaeological assemblages, the aetiology of the condition will be discussed with regard to both potentially recognising dwarf individuals in metrical data and any possible contribution to the development of OC depressions.

Metrical data from modern stillborn Dexter calves will be compared with archaeological specimens to challenge the identification of "foetal" calves, using standard metrical data from modern continental cattle breeds. Finally, selected archaeological finds of calf bones will be discussed in comparison with both the historical sources and the data from the Dexters.

3.1 Historical Information

The standard identification of a dairy based faunal economy from archaeological animal bones is based on the presence of a high proportion of, unsexed, infant mandibles and a complementary high proportion of adult mandibles and post-cranial elements. The latter show a skewed distribution of primarily females, from the measurements of sexually dimorphic bones, particularly the metacarpal. The interpretation of this pattern being that most bull calves were killed soon after birth, as being competitors with humans for the dam's milk, whereas most of the heifer calves were reared for herd replacements. In the modern world of the Holstein cow and industrialised dairy, such a pattern might be anticipated. This model presupposes a specialised pastoral economy with no complementary agrarian component, which Whittaker (1988, 1) argues has never existed. Once there is land under the plough, there is a continuing demand for oxen to work the land. Since oxen are normally castrated males, discussed further in Chapter 6, bull calves have to be reared for replacement draught animals. In Wales (Gidney & Caple 2007) and, particularly, in Ireland (Lucas 1989) the medieval economy was highly dependant on cattle and dairy products, considered in Chapter 4. Even in these comparatively specialised pastoral economies, oxen as well as bulls are enumerated with pride among the herds (Trow-

Smith 1957, 102), reflecting in Wales the arable of the low-lying hendre complementing the dairy of the upland hafod.

The Welsh laws (Wade-Evans 1909, 217-220) enumerate the quarterly incremental value of calves, Table 3:1, with a clear distinction made between "she calf" and "he calf". It can be seen that from birth until August of the third year both heifer and bull calves and young stock were of equal value. Like modern race horses, the age grouping and value of the young cattle were determined from a fixed calendar point, not the actual month of birth. Subsequently, and to be considered further in Chapters 4 and 6, the timing of the increments in value vary, reflecting either calf-bearing and milk production for females or yoking for the plough for males, but the end value remains the same. This equality in value between either heifer and bull calves or lactating cows and plough oxen is not propounded by any model of animal husbandry that presupposes preferential slaughter of bull calves as valueless.

i. Slaughter of the First-Born

It is of particular note that the value of a heifer increases at her first calf bearing but not until the second calf bearing does she have a "calf walking nine paces after" (Wade-Evans 1909, 217). This suggests some antiquity to the strongly held belief that the first calf of a heifer, regardless of sex, should not be reared as it would fail to thrive (Rider Haggard 1899, 47-8). While Rider Haggard considered this to be mere superstition, Eckles (1919, 163) demonstrated for both Jerseys and Holsteins that the first born calves were noticeably smaller than both the second and third calves from the same dams and the breed average. The ancient prohibition on the rearing of the first calf of a heifer strongly suggests this was originally observed empirically, before the stricture passed into folk lore. Regarding the antiquity of the practice of not raising the first-born calf, Wileman (2005, 103) notes the Biblical descriptions in Exodus of both the destruction of the first-born of men and, explicitly, cattle of the Egyptians and the subsequent dedication or sacrifice of the first born of man and all domestic livestock by the Jews. This concept of killing the first-born of both humans and livestock appears to have been widespread in pagan societies bordering the Mediterranean (Wileman 2005, 103-5). As a further practical consideration, Miss Roberts of the Vycanny Dexter herd (pers. comm.) alleged that if a heifer was allowed to suckle her first calf, she would not consent to be hand milked too. This slaughter of the first-born calf may have also arisen to facilitate milking, particularly in mobile

herds such as the Irish creaght (Lucas 1989, 70-71). After the first lactation, the heifer would be sufficiently accustomed to being hand-milked that the second calf could be allowed to suckle too.

ii. Weaning from Sucking

Walter of Henley's advice on calf rearing and weaning was to allow a bull calf to suckle his dam for one month. Thereafter, he was allowed the milk of three teats for the next week, two teats the subsequent week, one teat the following week and taken wholly from his dam at eight weeks (Oschinsky 1971, 333). A heifer calf was only allowed to suckle for three weeks before being reduced to three teats and removed from the dam at six weeks old. The three or four weeks while the cow was still allowed to feed her calf but the dairymaid also started drawing milk would have given a relatively stress free changeover from suckling to hand milking for both cow and dairymaid. This approach is well documented in all the husbandry texts subsequent to Walter of Henley, for example Thomas Tusser recommended weaning from suckling at 50 days (Hartley 1969, 127), but has yet to impinge on zooarchaeological discussions of milk let down (Mulville *et al* 2005, 179). The extended period of six to eight weeks suckling would have given the calf time to acquire more antibodies from the dam than the protection obtained from the colostrum. This would have helped avoid the digestive scour common to modern bucket fed calves. The cessation of suckling when calves were ingesting a substantial proportion of solid food would also have helped to prevent outbreaks of scour.

In the study of calf behaviour for unimproved Italian Maremmana cattle on range conditions (Tenucci *et al* 1986; Tenucci and Vitale 1991), it was observed that the cow/calf bond began to weaken after ten days and, by one month of age, the calves sought their dams just for suckling. It appeared that after the calves were about 50 days old, grazing was a more important food source than milk. This study strongly suggests that the medieval, and later, husbandry manuals advocating a gradual weaning of the calf from suckling its mother by 50 days were following empirical observation of innate cattle behaviour.

Morton Boyd and Jewell (1974, 367-8) observe that low nutritive status is reflected in the behaviour of wild ruminants, with such animals becoming listless. This might be expected in calves subject to early weaning. Fussell (1966, 56-65) gives an over-view of post-medieval ages of weaning. There appears to have been much

regional variation, with suckling of the dam allowed anywhere from one week to three months, broadly comparable with the earlier advice of Walter of Henley and Tusser. What is less clear is whether weaning at this age merely means removal from suckling and continued pail feeding of "flotten" or skim milk, or weaning in terms of a cessation of feeding any form of milk product. Thompson (2005, 135-7) doubts that the calves would have survived if fully weaned off milk at 50 days.

There are literary references to the presence at the same time of both a cow and calf and dairy produce. *Piers Plowman* (Skeat 1965, 77) famously had two green (soft) cheeses, a few curds and cream and a cow and calf among the scant list of provisions available until Lammas time, in August. In the wooing song of Henry VIII (Green 1899, 106-7), John enumerates his property to Joan to demonstrate his ability to support her and includes not only "my cow, my calf" but also "cheese upon the shelf, and I cannot eat it all myself". As Hellier and Moorhouse (1980, 1) point out, most surviving documents with information about dairy practices were concerned with the middle and upper ranks of society and little is known of the practicalities further down the social scale. Such mentions of not only a cow and calf but also to dairy produce could suggest that calf slaughter may not have been economically viable for lower social orders. An alternative implication might be that reference is being made to the transition period when the cow is being milked but still allowed to suckle her calf. Piers Plowman's curds and green cheese could equally support the latter interpretation, as these dairy products could be made without rennet.

iii. Calf Slaughter and Vellum

The 1325-6 account roll for Barnard Castle details 73 calves born in the accounting year from 77 cows, besides 67 yearlings which, as Austin (2007, 105) points out, suggests a high level of retention from year to year. This might reflect re-stocking after the devastating raid on the vaccaries in 1308 (Austin 2007, 71) and the agrarian collapse of 1315-1322 (Kershaw 1973). However infant calf bones are generally sparse finds on medieval sites prior to the 15th century, including Barnard Castle, even where preservational conditions are good. Thereafter, such infant calf bones occur in numbers at sites all over England, for example Hartlepool (Daniels 2010, 192), Leicester (Gidney 1991a & b) and Launceston castle, where Albarella and Davis (1996, 34) discuss this as a national phenomenon. All the standard interpretations covered by Albarella and Davis concentrate on the dairy exploitation

of the dam and the concomitant consumption of veal as a response to the decline of draught cattle, in turn linked to the rise of horse power. While these were doubtless important considerations, the calf hides would also have value. Gidney (1991a) considered the use of vellum in Leicester, given the proximity of Parchment Lane to the excavated site. Vellum was used for bookbinding as well as for writing. The scale of production of religious books required the sourcing of large numbers of skins of the same high quality. Reed (1972, 167) suggests that the production of the 35 copies of the Gutenberg Bible required about 6000 calfskins. However, the abundant finds of cobbling waste recovered from deposits dated c. 1475-1515 from the moat at Barnard Castle were principally of calf skin (Austin 2007, 540-552). A similar change with more of the later medieval shoes made of calfskin has also been observed in London (Grew & Neergaard 1988, 44-46), where it is suggested that production of English cordwain from calfskin was a response to disruption of supplies from Spain. The quality of calfskins for leather working is influenced by diet, sex and season. Reed (1972, 38-41) categorises the qualities of veal and calf skins, making a significant distinction between very young and older calves. The best skins are from milk-fed calves rather than those weaned on to solid food. Heifer calf skins are more valuable, being tougher and finer grained than those of bull calves. In Europe, calfskins are at their best from April to June.

The advice given by Markham (Best 1986, 168-9) to the housewife in charge of the dairy on the best time for calving, selection of calves for rearing and method of rearing may be seen as corroborating such springtime production of calfskins in the 16th century. For optimum production of milk, the end of March and all of April is seen as the best time for calving. The calves born then, regardless of sex or the merit of the dam, were not to be reared but sold to the butcher, having fed upon "their dam's best milk".

Zooarchaeological discussion of calf cull patterns tends not to consider the quality of the skin as a primary reason for slaughter, yet this could have been an important incentive for the slaughter of spring-born sucking heifer calves. The sudden appearance nationally in the late medieval archaeological record of a significant cull of calves is an event that might be considered to lead to change in the morphology of the cattle by selective culling, or “improvement”. Hall & Hall (1988, 491) point out that, under artificial selection, only the “better” 50% of the annual calf crop should be retained for breeding but that the natural calf mortality in the Chillingham herd

mirrors this optimum cull. High calf mortality could therefore reflect "survival of the fittest" rather than deliberate selection for a change in phenotype. This increase in calf slaughter also coincides with the increase in cattle and black rat size in the 16th century, discussed in Chapter 3 as a response to the "Little Ice Age" and so may also indicate a pragmatic response to worsening winter conditions impacting on the mortality of puny calves.

iv. Cheesemaking and Rennet

Natural souring will coagulate milk but these soft curds are acidic and cannot be stored for long. To make most hard cheeses with good keeping qualities, the milk needs to be coagulated before reaching such levels of acidity. This has traditionally been achieved by using rennet obtained from the stomach of a calf (Thear 1983, 48). Markham (Best 1986, 175) is quite clear that rennet is made from the stomach bag of a calf that has been fed solely on milk and that the curd within the stomach should be undigested. Similarly, Eliza Smith (1758, 100) advises that the calf should be allowed to suck his fill just before slaughter. Markham recommends laying up a good store of rennet bags at the beginning of the year. This may be the start of the accounting year in April, rather than the calendar year in January, as Markham (Best 1986, 168) advises that the best time to calve cows for the dairy is late March and all April, when the grass is "beginning to spring to its perfect goodness", but that all the calves born then should be slaughtered. Markham was writing with regard to southern England, so some regional variation in the optimal time for spring calving and calf slaughter might be anticipated, particularly in upland regions where there is little grass growth before mid May. Such a sequence of lowland then upland calvings would also produce extended availability of veal for either manorial lords with estates encompassing both types of grazing or urban centres supplied from such a hinterland.

The indispensable nature of rennet for the production of hard, keeping cheeses requiring in turn an annual spring slaughter of calves to produce the necessary rennet bags is a concept that has yet to be widely considered among those zooarchaeologists particularly interested in the faunal evidence for dairy herds. Even Mulville's (*et al* 2005, 173) consideration of "why do calves die" merely mentions calf slaughter as a means of liberating milk for human consumption.

v. Seasonality of Calf-Rearing

Markham (Best 1986, 168) recommends that only those calves born in October, or later in the winter, should be reared as "the main profit of the dairy is then spent" and these calves would suffice for “the maintenance of the stock, and upholding of breed”. Calves born in the "prime days" of summer were not to be reared as they were considered particularly prone to sturdy (Straiton 1972, 147-8). Tusser is more restrictive, recommending that only calves born between Christmas and Lent should be reared (Hartley 1969, 127), which might suggest that the calves born during the Lenten fast could be reared on their dam’s milk for consumption as veal at the Easter feast. If Markham's advice were to reflect common practice, one would expect a distinct seasonality of occurrence of veal calf bones in the archaeological record for the 16th and 17th centuries. Although cattle can calve at any time of year (Hall & Hall 1988, Hall 1989), this would not be apparent. Instead there would be a peak of veal calf bones in spring, about Easter time, coinciding with infant lambs, tailing off over the summer months with relatively few over the winter months. Dyer (2006, 205) tabulates the purchase of veal for the household of Dame Alice de Bryene, in Suffolk, for 1412-13, which does show such a bimodal pattern. Purchasing commenced in November, peaking in February which may reflect feasting, *carne vale*, before the rigours of Lent, shown by minimal purchases in March, recommencing in April. Most veal was purchased in May and June with a sharp decline in July and August. No veal was purchased in September and October. Assuming veal calf slaughter at 8 weeks, this pattern could imply rearing of most calves born January-February and all calves born July-August.

While both Tusser and Markham consider the time of year and the demands of the dairy to be criteria for calf slaughter, neither author makes any recommendation on the sex ratio of either the calves to kill or the calves to rear.

Detailed evidence of aseasonal breeding and calf survival from recent cattle populations is presented in Appendix 3: 1. Points arising complementing the historical sources and of relevance for the interpretation of archaeological calf remains are:

- seasonality of calving can indicate human herd management rather than natural biology
- calves born later than spring show lower mortality from cold, wet weather while fewer autumn born calves succumb to disease

- calves born in summer and autumn have lower body weights than those born in winter and spring. Smaller calves encounter fewer problems at birth and the dam puts body resources into lactation to enhance calf growth after birth.
- the advice on killing spring born calves and rearing autumn born calves for the dairy, given by Markham (Best 1986, 168-9), is vindicated by scientific observation and quantification of both traditionally managed dairy cattle and feral cattle.

The adaptation of modern cattle to local conditions, in terms of months of parturition and calf birth weights, is of particular interest in suggesting that the aurochs had the capacity to respond to post-glacial climate amelioration by a reduction in calf birth weights and an extended breeding season but this may only have manifested in the domesticated descendents. As observed for the Soays (Ozgul *et al* 2009), the survival of more of the smaller calves from primaparous females could rapidly impact on the mean body size of the adult population, whether wild or domestic. Other selection pressures, such as carnivore predation, may have diluted this effect in the wild aurochs.

vi. Selection of Traits in Calves to Rear

Much emphasis is placed by Markham (Best 1986, 168) on the selection of gentleness as a prime trait of kine for the dairy. Tusser (Hartley 1969, 127) stresses handling calves to gentle them for either the yoke or the pail. If friendliness were to have been an early criterion in the selection of which calves to rear, this could have wide-ranging implications for other aspects of cattle morphology. Trut (1999) has demonstrated the results of 40 years of selectively breeding foxes solely for tameness. Collateral changes in the foxes after 35 generations, which would be visible in the skeleton, include reduction in sexual dimorphism, changes to the skull and shortened legs. Other changes include variation in pelage, extended breeding season and aseasonal breeding. This long term breeding project, selecting for only one aspect of behaviour, has successfully duplicated many of the traits associated with all domestic species. The fox experiment has interesting implications for the early domestication of cattle. With beasts the size of the wild aurochs, friendliness would be a premium attribute. Given the current widespread interest in the antiquity of dairying, it is

possible that the pail came before the yoke and that cows were milked and calves were hand-reared before steers were trained to the yoke. Milk is, after all, an obvious resource from any female animal, whereas the concept of the yoke may have required thought.

vii. Artistic Representations

In medieval art, commonly reproduced and discussed images of medieval calves appear, for example, in both Bestiaries and Books of Hours. While both types of work have integral religious connotations, this is often forgotten when the images are cited and interpreted without reference to the original context. Detailed discussion of depictions of cows with and without calves follows in Chapters 4 and 5. Here, one example, which has been uncritically disseminated widely, will be considered. Plate 3: 1 is generally taken to depict a cow (Woolgar 2006, 95, Plate 7.1) licking her calf while being milked by the dairymaid, and used as evidence that the presence of the calf was necessary for the cow to let down her milk. In the original 13th century Bestiary (Barber 1999, 92), this picture illustrates the text taken from Numbers referring to the sacrifice of "a red heifer without spot, wherein is no blemish" and linking the red heifer as a symbol for the crucified Christ. From the discussion above (2.1 i), the re-interpretation of this image is based on the fact that the dam is explicitly a heifer, therefore indicating that the bull calf she is licking has a very short life expectancy. The calf is plump and well-grown and may be near the end of his allotted eight weeks with his mother. Linking the textual with the pictorial evidence aids "reading" of the image, rather than taking it out of context to bolster modern pre-conceptions.

The two bull calves gambolling exuberantly in Plate 3: 2 are from the same Bestiary (Barber 1999, 93-4) and are illustrating the phrase "to skip like a calf", besides being symbols of innocence whose necks are "a stranger to the yoke of sin" and sacrificial animals, again used as a symbol for Christ. The calf in the foreground is clearly an entire male, suggesting that castration of infant bull calves destined for the yoke may not have been the norm. Though these illuminations lack the naturalistic detail of later medieval illustrations, the artist has admirably conveyed the vitality of well-fed calves. All three calves appear to be about the same age, are well-fed and there is no indication of horns, though the red heifer is horned, with the possible implication of an age less than fifty days old and a destiny as veal.

3. 2 Data from Modern Herds and the Dexter and Jersey Reference Skeletons

Three topics will now be considered as contributing to the methodological requirement of bridging the divide between "known" modern comparative data and the "unknown" factors contributing to the archaeological record (Thomas & Mainland 2005, 4). Firstly, Dexter calf birth weights are used as a proxy for the range of variation within and between herds of one breed. Secondly, metrical data from commercial cattle breeds used for the estimation of gestation stage are contrasted with data from Dexter calves. Thirdly, the manifestation of chondrodysplasia in calves is discussed.

i. Birth Weights of Dexter Calves

Detailed discussion of calf birth weights as proxy information for:

- variation in the size of neonatal calves
- mean size difference between male and female neonatal calves
- survivability of neonatal calves
- inter- and intra herd size variation
- dystocia
- seasonality of calving

is presented in Appendix 3: 1. Here, the application of such topics to a Dexter dataset, as a proxy for the archaeological record, is presented.

The DCS Herd Books published birth weights of calves from two herds in 1983, rising to 28 herds by 1991. Subsequent birth weight data have been kindly provided for the Harron herd for 1992-2000 and for the Nutlin herd for 1995-2007. This is an accessible, quantifiable dataset of a geographical spread of herds for analysis, contrasting with the restricted suite of metrical data from the reference skeletons.

In particular, these Dexter data were seen as a useful test of the conjectured birth weights and survivability of heifer calves proposed for the Chillinghams (Hall & Hall 1988), and, by extension, archaeological cattle subject to similar minimal husbandry inputs. Joubert & Hammond (1954, 648) stated that the Dexter breed mean

birth weight was 52.3lb (23.7kg) but gave no indication of sample size, range, standard deviation or the source of data, since this information was not published in the 1950's DCS Herd Books.

The Knotting herd (see Appendix 3: 1) was a comparatively large dairy herd, so data from this herd are initially considered separately, to avoid skewing the overall trends. Figure 3: 5a shows the range of weights recorded for all herds except Knotting and Figure 3: 5b separates these data into bull and heifer calves, with the sexes shown individually in Figures 3: 5c-d. Figure 3: 5e also displays the same data for the heifers but in pounds, to act as a check on the results obtained by the metric conversion. The overall patterns obtained in Figures 3: 5d-e for the heifers are sufficiently similar that the converted data can be used with reasonable confidence for overall trends.

The data presented in Table 3: 2 confirm Hall and Hall's (1988, 490) suggestion that bull calves should be, on average, heavier than heifer calves. Though, as anticipated, the small size of the Dexter breed is reflected in a mean difference of only 2kgs between the sexes, comparable with data from Australian range cattle (Holland *et al* 1977). However, as Figure 3: 5b comparing bull and heifer weights shows, a simple statement of a 2kg mean difference in birth weight, fails to indicate the broad overlap of weights between the sexes within two SD of the mean, nor the extreme range. Both the very smallest as well as the very largest calves recorded are bulls. It can be appreciated that rearing either the extremely small, or the extremely large, calves as breeding bulls could have a major influence on the birth weights of the succeeding generation. In contrast, retaining breeding stock from within one SD of the mean size would maintain the average size range. It is this normal tail of variation beyond two SD of the mean that can allow both natural and human selection on livestock populations to produce a rapid change in phenotype to meet changing requirements for survival, without invoking any change in genotype or "improvement".

The Knotting herd contrasts one management system in one geographical location with the data from a variety of small herds throughout the country on a broad spectrum of management and feeding systems. Less variability might be expected in the Knotting data, which could also mimic the founder effect on small cattle populations postulated by O'Connor (2003, 183-4). Figure 3: 5f shows the distribution of birth weights for the Knotting herd and Figure 3: 5g compares these data with those from all the other herds. It can be seen that the Knotting distribution

falls within the range established for the other herds, while Figure 3:5h, including the Knotting data, enhances the pattern already established in Figure 3: 5a for the other herds. Figure 3: 5i shows the weight distribution of Knotting heifer calves and Figure 3: 5j that for Knotting bull calves. The bull calves show a normal balanced bell-curve distribution, whereas the heifers show a skew towards the heavier calves. This is certainly not a scenario considered by Hall & Hall (1988, 490) for the Chillingham herd. As anticipated, Figure 3: 5k comparing weights of full term live born bull and heifer calves indicates that more of the heavier calves are bulls. However, Table 3: 3 demonstrates a mean difference of only 1kg between Knotting bull and heifer calves. Adding the Knotting data to that from the other herds has not resulted in any major alteration to the mean or SD.

Meticulous records of weights for premature and stillborn calves were kept for the Knotting herd. Figure 3: 5l compares the weights of full term live and stillborn calves. It can be seen that there is no apparent correlation between weight and still birth. Figure 3: 5m incorporates the weights of both live and still born premature calves. It can be seen that some of the very smallest calves were viable, with modern husbandry, while others within the normal full term weight range were not. This concurs with the study of Jerseys by Richardson *et al* (1990, 282), who found no significant difference between 260 day foetuses and full term calves in terms of bodyweight, which was therefore not an accurate indicator of developmental age in the late stage of gestation.

As calvings occurred throughout the year in the Knotting herd, Figure 3: 4, data on birth weights by month are shown in Table 3: 4. The Knotting cattle were well fed and housed in winter in a temperate climate, therefore the monthly birth weights do not reflect the response to extremes of hot or cold weather seen for American and Australian calves (Colburn *et al* 1996; Holland *et al* 1977). A minor response to winter weather may be indicated by the heaviest Knotting calves being born in February.

Selection in the Knotting dairy herd was for the short-legged type, so produced both short and non-short calves. In contrast, the Harron herd is an exclusively non-short beef suckler cow herd, hence all Harron calves are non-short. A comparison of these two herds should therefore test where the non-short calves fall within the range of birth weights already established. Figure 3: 5n shows the distribution of birth weights for the Harron Herd, separated by sex in Figure 3: 5o.

Table 3: 5 shows that the exclusively non-short calves are not reflected by any substantial difference in birth weight. Rather, the mean birth weight of 21kg appears to be standard to the breed. The range is comparable to both the Knotting and whole breed data, lacking only some of the heaviest examples, but the SD is slightly reduced. The smallest calves are heifers, rather than bulls, and both bull and heifer calves lie at the top of the range. What is apparent for both the Knotting and Harron data is a reduction in the difference in mean weights between bull and heifer calves from a single herd compared to the sample of the broad population. This impinges on Hall & Hall's (1988, 490) application of mean birth weight data from commercial cattle to the Chillinghams, which are a homozygous population.

This detailed examination of the variation in birth weight of Dexter calves is intended to show that birth weight can be a useful tool at population level. However weight, size and viability are subject to considerable variation. Understanding this is necessary before attempting the interpretation of single examples, or small samples, of archaeological specimens as stillborn, foetal or perinatal animals.

ii. Age Estimation of Foetal and Perinatal Calf Bones

The data discussed for birth weights have been a proxy for the variation in size that might be anticipated in the bones of new born calves. The length of infant calf bones is an important attribute for the estimation of the stage of gestation for foetal or perinatal bones. Gestation is normally presumed to be 280 days (Hall & Hall 1988, 482). Richardson *et al* (1990, 282) observed a decrease in growth rate from 260 days gestation to term in Jersey calves, together with greater variability between individuals and no significant difference in bodyweight, leading to a decline in the accuracy of estimating developmental age. While this suggests that the separation of late foetal and full term calves is a less than exact science, Richardson *et al* (1990, 283) observed significant differences in the diaphysial lengths of the radius and tibia between 260 and 280 days gestation, an attribute of direct relevance to archaeological finds.

Prummel (1989) provides data established to estimate the foetal age for German Black and White Lowland breed, Simmental and Fribourg cattle breeds. These data are widely used, without necessarily considering whether breeds with adult cows standing at 1.3m and bulls at 1.4m are entirely appropriate comparanda for archaeological cattle. Richardson *et al* (1990) produced a dataset of Jersey calves. The

average Jersey cow withers height is also about 1.3m. Unfortunately, although the left limbs of these calves were fully defleshed, the measurements of diaphyseal lengths were taken from radiographs, a standard veterinary practice, not the clean bones. Only data for the radius and tibia are published, whereas metapodials are more common archaeological finds (Serjeantson *et al* 1986; Scott 2000). Although the full data set is stated to be available in the Central Veterinary Laboratory library, enquiry of this institution failed to locate the work in question.

The similarity in adult cow height may be reflected in the broad concordance in Table 3: 6 between the Jersey and Simmental/Fribourg data for the mean lengths of foetal bones. While the mean calf bone sizes for these breeds are comparable, suggesting standard foetal development, the range and SD remain problematic in the interpretation of the usual archaeological find of a single infant calf bone.

Calf bones survive extremely well in the calcareous sands found in the outer Scottish Isles (Mulville *et al* 2005) and also on mainland coastal sites such as Freswick, Caithness (Gidney 1995) and Green Shiel, Lindisfarne (Scott 2000). The Lindisfarne finds are thought to possibly represent refuse from vellum production, due to the preponderance of metapodials, suggestive of skin processing. However, there are also seven radii for comparison with the seven radii from known stillborn, full term Dexter calves. There are no calf tibiae from Lindisfarne. Table 3: 7 presents these data for comparison with the foetal Simmentals and Jerseys in Table 3: 6.

It can be seen that the full term Dexter calves fall within the late foetal size range for the Simmentals and Jerseys. The Lindisfarne bones are larger than the Dexters but still only just fall into the perinatal range for the modern breeds. The implication is that application of these modern data to archaeological finds might well be misleading, and will be considered further in section 3.4.

iii. Chondrodysplasia in the Dexter

The dwarfism in calves mentioned as present in the Knotting, but not the Harron, herds of Dexters will now be considered in more detail. While the breeding of a dwarf may be inadvertent, rearing the dwarf can indicate active decision-making on the part of the herder, a management practice not widely considered for archaeological assemblages.

Chondrodystrophy, chondrodysplasia and achondroplasia are virtually synonymous terms indicating defective development of the cartilage of the long

bones, particularly the epiphysial plates, resulting in arrested growth and dwarfism. Most forms of this dwarfism are a simple autosomal recessive trait. Crew (1924 a & b), Usha *et al* (1997) and Cavanagh *et al* (2007) provide detailed analyses of the genetics of dwarfism in Dexter cattle. The short-leg Dexter is a heterozygous carrier of this gene while the non-short Dexter is a homozygous non-carrier. The bulldog calf associated with breeding short-leg male onto short-leg female Dexters is the lethal homozygous expression of this form of dwarfism, with the foetus being aborted at about 7 months gestation. Plates 3: 4a-e show the sole example of a bulldog calf born in the Zanfara herd.

Before science proved a genetic origin for bulldog calves, external agencies were believed to be responsible. Such an assumption was partly justified as some manifestations of chondrodystrophy in calves are not genetic in origin. In Acorn Calf syndrome, the severe shortening of the long bone diaphyses appears superficially similar to the short-leg Dexter (Hawthorne and Kent 2006) but results from an impact on foetal development between 45 and 245 days gestation. Viral infections, plant toxins and dietary deficiencies are potential causes.

Genetic forms of bovine dwarfism are geographically widespread among a variety of breeds including Florida Cracker, Jersey, Hereford and Aberdeen Angus in North America; Telemark in Denmark and Japanese Brown in Japan, besides the Dexter in Britain. The occasional birth of dwarf calves or aborted monstrous foetuses is reported as a curiosity in an even broader spectrum of not only cattle breeds but also domestic buffalo, reflecting the multitude of dwarfism phenotypes that occur in nature (Koltes *et al* 2009, 19250). In the mid 20th century, dwarfism became endemic among American ranched Herefords and Angus. Initially this was exploiting a fundamental association, also relevant to the Dexter, between shortness of leg with thickness of conformation and earliness of maturity. Such shortening and thickening of bones is associated with shortening and thickening of muscles, resulting in plump cuts of meat, though with little alteration in the percentage of meat to bone (Guilbert and Gregory 1952, 9-10). Eventually, this was carried to extreme, causing substantial economic loss through slow growth and small carcase size (Koltes *et al* 2009, 19250). At the same time, the DCS in Britain only accepted the short-leg heterozygote as the breed standard, leading to the average loss of half of all calves born as either bulldog calves or non-shorts unacceptable to the breed standard, and the Dexter came close to extinction. This explosion of dwarfism can be directly attributed to the use of carrier

bulls and inbreeding. The example of dominant achondroplasia in an American Jersey herd was directly traced to a single sire and subsequent sire on daughter matings (Mead *et al* 1946, 186). Prior to the development of genetic tests, much effort was expended on eliminating the Hereford dwarf (Bone 1963). Gregory (*et al* 1966, 396) recognised several distinct achondroplastic phenotypes in the Hereford, Shorthorn and Angus cattle studied, leading to experimental matings to reconstitute cattle with the Dexter dwarf genotype. Koltes *et al* (2009, 19250) summarise the differing genetic causes of dwarfism in Dexter and Japanese Brown cattle and show that the re-appearance of dwarfism in American Angus is genetically separate.

For several reasons, it is highly unlikely that dwarfism in cattle in earlier epochs could have reached the endemic levels seen in the 20th century. When the principle purpose of male cattle was for the yoke, there would be no incentive to rear a calf that would not be of level size with its future team mates. The plumpness associated with the short-leg Dexter bull calf would also make a desirable veal carcase. If no carrier bulls were used, then the dwarfism would descend solely through the female line and no homozygous bulldog calf could be engendered. Rapid increases in the incidence of dwarf calves are all traceable to inbreeding back to one carrier animal. Inbreeding and line breeding were promulgated as new techniques by the 18th century improvers, whereas incestuous breeding was previously avoided. Outbreaks of dwarfism in American range beef cattle were difficult to contain where there was little individual human-animal contact. Such management systems were previously unknown.

Baker and Brothwell (1980, 41: Fig. 4) illustrate an archaeological find of a calf humerus, identified as dyschondroplastic, from the Neolithic site at the Knap of Howar. Dwarfism would thus appear to have been present among the earlier domestic cattle in Scotland. The fact that this bone is from an infant calf supports the contention that such calves would be less likely to be reared, particularly if male, thereby preventing the increase of carriers within the herd.

Besides visual examination, metrical data might be expected to separate dwarf from normal individuals. Tyler (*et al* 1961) defined three metacarpal indexes to separate Hereford dwarf from control cattle: Total Length/Diaphyseal Length, Total Length/Diaphyseal Diameter and Diaphyseal Length/Diaphyseal Diameter. Prepared bones were used to avoid the error caused by adhering soft tissue. The indexes were calculated from both fused and unfused bones and the sample included veal calves,

heifers, steers and cows but not bulls. While this appears a useful method for identifying the proportion of dwarf cattle in a population, unfortunately the selected points of measurement (Tyler *et al* 1961, 694) differ in detail from those defined by Driesch (1976), so cannot be applied to existing zooarchaeological datasets. The requisite large sample of complete metacarpals is also rarely encountered on sites other than Roman forts and towns. Similarly, Howard (1963) devised two metapodial indices, Distal Breadth/Length and Midshaft Breadth/Length, which have been more widely applied to archaeological cattle bones in an endeavour to separate bones of cows, steers and bulls. While the basic principal of both methods is sound, both are potentially flawed in the interpretation of results if applied to a population encompassing cows, dwarf cows, steers castrated as calves, steers castrated as young adults, bulls and cattle of differing phenotype, such as might be anticipated in a major population centre with extended supply lines. Tyler *et al* failed to include bulls, whose comparatively short and robust metacarpals might fall towards the dwarf index, and Howard failed to consider the presence of the dwarf, which might overlap with the bull index. The possibility of devising related indices for the reference collection of Dexter skeletons with which this study is concerned is beyond the scope of the present project.

As described in Chapter 2, OC encompasses depressions within the epiphysial growth cartilage (Ytrehus *et al* 2007). The genetic nature of the chondrodysplasia in short-leg Dexters might be anticipated to be a predisposing factor for OC. Ytrehus (*et al* 2007, 437) note that inheritance is an important factor in the aetiology of OC but that there is an absence of studies evaluating the presence of early depressions. The juvenile Dexter reference specimens will therefore be examined to record the incidence of such depressions.

3.3 The Dexter and Jersey Reference Skeletons

The young animals form the majority of the reference specimens but this was not an intentional collecting policy which, at the time, was concerned with longevity. Collection of bones was mostly incidental to the butchery of carcases so few complete skeletons are represented.

Since the stages of tooth eruption and wear and epiphysial fusion are of fundamental importance in the analysis of archaeological assemblages, the animals

represented in the reference collection are grouped by age and breed cohorts for discussion of life histories, skeletal ageing and abnormalities.

i. Stillborn calves

Still born Dexter calves were obtained from the Vycanny and Butterbox herds, in addition to mortalities in the Zanfara herd. To put these natural mortalities in perspective, the Zanfara herd produced 97 live births (51 heifer calves, 46 bull calves) from 1989-2009 but only six still births and one aborted bulldog foetus. One still born calf was a twin to a live sibling. The second bovine twin is usually a breech presentation, which is rarely delivered alive without assistance (Straiton 1988, 54). Even with part-time husbandry, a traditional approach to stock-keeping can produce low infant calf mortality rates, which could be even lower with full-time husbandry.

An infant calf skeleton, of a modern commercial continental cross breed, was collected as clean bones from a neighbouring farm. Unfortunately, Table 3: 8 shows that several of the calf skeletons, prepared in the 1980's, have been mislaid.

ii. Sucking calves

Mortalities of older calves have been very rare. No other herd had any to offer when reference skeletons were being actively collected for this project. Within the Zanfara herd, only four older calves have died. Details of the parentage and lifespan of these calves are presented in Table 3: 9.

Dozey was short-legged and early development appeared normal. However, when the cattle were turned out, it was apparent that he was unable to walk after his dam. Veterinary inspection resulted in no clear diagnosis and no response to medication. That year saw a regional epidemic of rotavirus, on a scale that might have merited mention in a medieval chronicle as a murrain. Large numbers of calves died and those that survived were unthrifty. Symptons of rotavirus can include loss of mobility but a continuing interest in food. Other than being unable to stand, Dozey appeared well in himself and retained a healthy appetite. Since hearsay at the time included reports of eventual recovery by calves afflicted with rotavirus, Dozey was given the chance to recover, rather than being put down. He was stood up daily and supported on bales of straw, while his limbs were extended and massaged. He died suddenly, aged circa 5 months. A suite of pathological changes is apparent, examples in Plates 3: 5a-e, assumed to be a response to the long time that the calf spent

recumbent. This may have contributed to the eburnation on the glenoid fossae of both scapulae, with associated eburnation and pitting on the heads of the humeri. However, Dr Tina Jakob kindly examined the specimen and suggested that the exostoses on the proximal lateral diaphyses of both femora, Plates 3: 5a-b, are in fact a response to bilateral hip dysplasia. This condition is uncommon in cattle but is associated with the Hereford breed (van Vlierbergen *et al* 2007). Of relevance to the case of Dozey is the fact that affected calves do not show clinical lameness at birth and that hip dysplasia in calves appears to be sex-linked, manifesting only in males. A possible differential diagnosis is that the initial problem may have been meningitis and the hip dysplasia was caused by, rather than a cause of, recumbancy.

Tinkerbel was a Jersey x Angus heifer, double suckled on a Dexter cow. Scour was endemic within the Jersey herd supplying the calves and was transmitted to the Dexter calves. By the time it became apparent that Tinkerbel had contracted a more severe condition than the common calf scour, it was too late to save her. She died aged circa 10 weeks old.

Gundrada was a non-short Dexter heifer. At turn out, Gundrada galloped round the field with the other calves. Four days later, Gundrada was unable to stand up. Veterinary opinion was immediately sought, with a diagnosis of meningitis. Like Dozey, supports were used to try and help her to stand. By the second week, she had failed to respond to medication, lost her appetite and consequently lost body condition and died aged c. 6 weeks old. Only one mandible and the principal bones from one fore-leg and one hind-leg were salvaged.

Luke was a short-leg Dexter bull calf, found dead when away on summer grazing. The cattle were looked over twice daily and no signs of ill health were observed the previous day. The skull, one fore-leg and one hind-leg were retained.

iii. Weaned Dexter stirks

No weaned stirks were offered to this project from other herds. The only mortality in the Zanfara herd was by mischance, Jaquobina, a heifer whose skeleton was sold.

In contrast, several young weaned bulls have been deliberately beefed at less than a year old. Medlar was a short-leg, killed in November aged seven months. One hind leg, exhibiting the plumpness associated with short-leg conformation, was cut as a single joint for Christmas dinner. Post-weaning culling at such a young age reduces

the herd before the onset of winter weather and so saves on fodder. In contrast to archaeological interpretations, there was no association with milk let down and dairy exploitation of the dam. The motivation for slaughter was a magnificent joint for festive dining, rather than the usual impetus of straitened circumstances. Only bones from the dressed carcase were returned by the butcher. All the epiphyses, including the scapula tuberosity and acetabulum, are unfused. The vertebrae have the neural arches still in the process of fusing to the centra. This is a good example of a specimen that would be classified as a "calf", if found archaeologically, whereas Medlar was far from being a calf in size, behaviour or meat quality. In the absence of the mandible, which would give the more accurate indication of age, it was difficult to suggest how to assess the age at death. Mere size is insufficient in the case of the short-leg Dexter, though the dwarfism is particularly evident in the proximal radius, which has a pronounced lip on the medial aspect, Plate 3: 6. The one measurable bone is the astragalus and even this might not survive intact in an archaeological deposit. The texture of the diaphyses has the smooth surface of adult cortical bone while the epiphysial plates show the detailed modelling depicted by Schmid (1972, 153). This contrasts sharply with the woven bone of the diaphysis and the amorphous epiphysial plates seen for the infant calf. Bone texture may therefore suggest a very broad indication of relative age in such young animals.

iv. Jersey grass-fed veal calves

From 1989 to 1996, pure and cross-bred Jersey calves were sourced from one farm for the Dexter cows to suckle alongside their own calves. The cross-bred bull calves were run on for beef while the pure Jersey bull calves were kept for grass-fed veal. The Butterbox herd was promoting this practice as a way of producing ethically reared veal (Garratt & Garratt 1988). The pure Jersey calves were not kept with the aim of providing reference skeletons, though some bones from a few of these calves were retained. The interest of these calves is in the mortality profile, compared to the natural fatalities described above. Although a very small sample, it can be seen from Table 3: 10 that the spring born calves, finished outside on grass, were younger at slaughter than the summer born calves that were finished indoors on hay. Due to modern welfare regulations, all the Jersey calves were weaned at least a week before slaughter.

Major limb bones, though not metapodials, are extant from Edward and another calf of similar size, possibly Victor, with the addition of metatarsals. A set of chopped metapodials may derive from Stuart, whose skin, with feet in, was exhibited at the AEA conference in Durham in September 1993. This example corroborates Sejeantson *et al's* (1986) interpretation of the Kingston calves' feet as indicators of skins.

Lacking the mandibles, a comparison of Edward with Medlar shows no obvious differences in the skeletons to indicate the difference of one month in age between the two. As to be expected, Edward has longer and more gracile limb bones than Medlar and the astragali in Figure 3: 9d show a marked size difference. In contrast, their ischia are broadly comparable in size. The normal gentle simmering used to clean bones has impacted on the condition of Edward's bones, which are very greasy with flaking of the surfaces of the cortical bone of the diaphyses and crumbling of the epiphysial ends. It is unlikely that these bones would survive long if buried, whereas Medlar's bones are much more robust and have cleaned well, as seen for the radii of Medlar and Edward, Plate 3: 6. Edward has none of the OC observed for Medlar in Tables 3: 14-15 below.

In 2010, some bones from a 6 month old Guernsey male calf, reared for rose veal, were purchased from Boccadon farm in Devon. It was thought these bones would be a useful comparison with the 6 month old Jerseys. In fact, these Guernsey bones provide a valuable indication of the growth rates achieved by modern housing and feeding of the castrate. The scapula tuberosity and acetabulum are unfused, indicating the youth of the animal, but the bones are massive, for example the astragalus in Figure 3: 9d. It is unlikely that any zooarchaeologist finding the astragali of the Dexter Medlar, the Jersey Edward and this Guernsey in the same context would consider that all three animals were roughly the same age and two of similar phenotype.

This example demonstrates the problems inherent in using metrical data from an element with no fusion event to give a "greater than" age estimate. Also, correlating size with "improvement", without defining the term, can be misleading. The Boccadon calf is "improved" in that it is much the largest, but this is due more to feeding than breeding. As discussed below in section 3, historically the best quality veal was "small and white". Large and pink veal would not have been esteemed for its eating quality. The housing and feeding needed to produce such huge "veal" carcases

requires capital and a high input-high output feed and labour system, vulnerable to changes in costs beyond the control of the husbandman. The cost of rearing the Boccadon calf was £450 for the feed alone, exclusive of the building, butchery and all other overheads (www.boccadonfarmveal.com). To put this in perspective, the author sold a Dexter cow in calf and with calf at foot for £400 in 2012.

The low input-low output system of the Zanfara herd is more akin to traditional husbandry, which was concerned with the profit to be realised, not the amount of meat produced. This is an important distinction which is rarely considered by the zooarchaeologist. A small quantity of high value product is better for the land and the livestock than commoditisation yielding a large quantity of low value product.

v. The Beef Dexters and Jersey Crosses, up to 30 months old

The young Dexter bulls and the male Jersey crossbreeds in the Zanfara herd were reared for meat. The abattoir returned bones from the dressed carcase but not the head and feet, so there are no complete skeletons.

The Butterbox herd kindly donated some bones returned by the butcher from one steer and one bull, which included the heads. There are complete skeletons of two steers, bred in the Vycanny herd but reared in the Zanfara herd. Collection ceased subsequent to the 1996 ban on beef on the bone. To reduce the bulk of these incomplete skeletons in store, only appendicular elements were retained for some beasts. Those animals for which some bones are extant are detailed in Table 3:11. Figure 3: 6 shows the age distribution of the cull cohort of all Dexter males deliberately beefed from the Zanfara herd, including those for which there are no surviving bones. Figure 3:7 shows the age distribution of the deliberately beefed males for which some bones are extant, while Figure 3: 8 includes the Jersey crosses. It can be seen that males were beefed as soon as there was any vestige of condition on them, with the major imperative being to reduce the herd before winter and the commencement of feeding conserved forage. The larger Jersey crosses therefore mostly fall at the junior end of the spectrum. A few beasts were wintered twice before slaughter. One of these was a young bull who was used for breeding for one season. One bull was deliberately run on to almost 30 months to provide outstanding beef for the author's landmark birthday party. One was the steer Carrot, bought-in as an infant calf from the Vycanny herd with the intention of growing on into a draught ox (see Chapter 6). There was no cow available to double-suckle Carrot so he was bucket

reared on one sack of proprietory calf milk and weaned from that onto grass with no other supplement, a modern equivalent of total weaning at fifty days. While this was an inadvertent interpretation of the 13th century didactic treatises, previously discussed, Carrot is a good example that such early total weaning is possible but not probable. Carrot survived but was a stunted listless calf and nearly succumbed to hypothermia in the winter.

For the incomplete skeletons, rather than discussing the individual animals, these will be considered as a group, comparable to an archaeological assemblage representing secondary butchery waste from the cutting of sides of beef where the primary waste, heads and feet, had been disposed of previously. Although the mandibles and metapodials are of the greatest potential interest to the zooarchaeologist, they do not necessarily travel into the archaeological record in association with the rest of the carcase. The bones of the appendicular skeleton had been boned out and the beef returned as boneless packages. This reinforces interpretations of such bones as culinary use of the marrow, not consumption of the associated meat. The principal bone-in joints, when this was permitted, were of the axial skeleton: the rib roast and sirloin. These high value joints would be represented by ribs and vertebrae, of little interest to the zooarchaeologist.

The main comparative interest of this group for zooarchaeological interpretation is the epiphysial fusion data, presented in Table 3:12 for the Dexters and Table 3:13 for the Jersey crosses. Despite the overlap in calendar age of the Dexters and Jersey crosses in Figure 3: 8, a comparison of Tables 3:12 and 3:13 would suggest that the Jersey crosses, with unfused epiphyses in the first grouping, were a younger cohort than the Dexters. This difference is certainly not a reflection of any dichotomy in feeding or management, as all were reared from infancy in the Zanfara herd. There is therefore an interesting possibility of a breed-related difference in skeletal maturation rate. The high proportion of fusing epiphyses seen for the Dexters is not encountered in the generality of Roman and medieval archaeological assemblages, suggesting that animals at this developmental stage were not normally slaughtered. The youth of the animals is indicated by the bones with clear fusion lines present in the first grouping. The distal trochlea of the humerus has fully fused in all the “just-fused” examples but the fusion line bordering the olecranon fossa is still clear. The proximal radius has fully fused in the 11 month old Dexter, in contrast to the unfused proximal radius of Medlar at 7 months old. However, Sienna, the Jersey

cross aged slightly less than 11 months, has the left radius proximal epiphysis fusing but the right epiphysis still unfused. The smooth cortical bone of the diaphysis indicates that this was not an infant calf but if these were archaeological specimens, an age disparity between the two bones would be assumed. The general balance between fusing and fused epiphyses is as anticipated from the known ages of the animals and suggests that epiphysial fusion as an indicator of age groupings is of some value for an assemblage. However, the moral is that the right result has been gained for, in effect, the wrong reasons. At the individual level, the well-fed Butterbox beasts appear skeletally older than some of the chronologically older Zanfara beasts kept in less favourable conditions and the Jersey crosses appear skeletally younger than Dexters of the same calendar age. This is a useful analogy for archaeological finds from, for example, urban deposits supplied from a wide hinterland where the overall pattern may indeed reflect the cull cohort despite vagaries in the rate of maturation of individuals. The Jersey crosses also serve as a cautionary example in the interpretation of unfused epiphyses in the first grouping as "calves", in the sense of sucking calves, without consideration of either the size or the stage of ossification of the diaphyses.

In keeping with the strategy discussed in Chapter 2, and the limited range of fused, measurable bones, only the distal trochlea of the humerus and the astragalus of these specimens were measured. Figure 3: 9a shows a scatter of astragalus measurements, which would suggest in an archaeological context a split into females, steers and males. Figure 3: 9b adds the two adult breeding bulls to the distribution, while Figure 3: 9c separates the young males into entires and castrates. It is clear that, at this age range, castration is not changing the absolute size or the proportions of the astragalus. Figure 3: 9d plots the young Dexter males against the Jersey crosses. There is a clear separation with the Dexters forming a discrete group, despite the age range, and the Jersey crosses being much larger in absolute terms than the Dexters and dividing by size into two pairs, reflecting the two younger and two older animals. However, the Jersey calf Edward lies with the older Dexter males and the Boccadon Guernsey is far larger than even the oldest of the Jersey cross males. If this were an archaeological sample of raw measurements with no reference to comments on the surface texture of the bones, one possible interpretation would be three entire males, two steers and the remainder females. An alternative explanation could include the presence of "improved" stock, which would be closer to the real scenario.

A rather different pattern is exhibited by the spread of humerus measurements in Figure 3:10a. Without knowing that these were all male, an archaeological interpretation would suggest one anomalous large animal, possibly a bull or "improved" type and a mix of smaller females and castrates. In the absence of the heads and metapodials, there are no independent values to establish the sex ratio in this sample, other than these metrical data. Plotting the castrates and short-leg animals against the entire and non-short animals, in Figures 3: 10a-b, demonstrates that both castrates and short-legs can lie at both ends of the spectrum. The adult bulls in Figure 3:10a lie at the larger end of the scale but there is no clear separation between the adult short-leg bull and the young males. Similarly, the Jersey crosses in Figure 3: 10c lie beyond the larger end of the young Dexter male range but extending this range rather than forming the separate distribution pattern seen for the astragali in Figure 3: 9d.

A secondary comparative interest of this group for zooarchaeological interpretation is the presence of hereditary or congenital skeletal traits. The most extreme example is displayed in the posterior cervical and anterior thoracic vertebrae of Apicius. The vertebral centra have failed to develop and fused into a block, Plates 3: 7a-b. There were no obvious physical abnormalities in the live animal as these vertebrae are encased in deep muscle in life, with the thoracic vertebrae lying behind the scapulae. The sacrum shows major asymmetry, with the sacral wings on two separate vertebrae, rather than both on the first sacral vertebra. Reconstructing the sequence of lumbar and sacral vertebrae was hampered not only by the splitting of the vertebral column but also the cutting of the two sides of beef by different people with slightly different preferences in dividing the vertebrae. It is therefore not clear if there is a lumbariform sacral vertebra or *vice versa*, Plates 3: 8a-b.

Given the difficulty encountered in reconstructing these anomalous vertebrae from fragments of one known individual, it is improbable that this condition would be recognised in an archaeological assemblage. Carrot exhibits a similar asymmetric sacrum. This is readily recognisable in the complete bone but had it been split, it is unlikely that the two sides would be identified as conjoining. The aetiology of this condition (CVM) was discussed in Chapter 2 for Cyclone. The incidence of CVM in such a small sample of eleven beasts is of interest, reinforcing Agerholm's (*et al* 2001, 283) statement that malformations of the axial skeleton are common congenital defects in cattle. Such conditions are rarely described for archaeological finds, for

several reasons. The recording systems in common use generally do not include the vertebral column apart from the atlas and axis. Unthrifty calves, like Apicius, would be prime candidates for culling as veal, reducing the survival and visibility of vertebra affected by CVM. Splitting of carcases into sides of beef can reduce the possibility of recognising asymmetric vertebrae.

A minor vertebral anomaly that has been observed archaeologically (Stallibrass 1983) is bifid spines on thoracic vertebrae, present in the Jersey cross, Thunder. This feature is associated with the humped withers of Zebu cattle but also occurs as a non-metrical trait in taurine cattle, such as the Italian Modicana breed (Cymbron *et al* 2005). The aetiology in taurine cattle may also be a result of asynchronous development of the foetus, in common with other manifestations of CVM.

The notch on the caudal border of the ribs, described in Chapter 2, is present not only among the Dexters, where ribs are extant, but also in the Jersey cross Thunder, further suggesting that this is a normal feature *contra* Holmes (1981). One rib of Thunder also exhibits a fracture in the process of healing, an occupational hazard in a young male running with the King Bull.

Further to the ongoing debate on the aetiology of OC, Tables 3:14 and 3: 15 show the distribution of such depressions on the articular surfaces of the Dexter males aged 6-30 months and the Jersey crosses aged 11-30 months. Metapodials and phalanges are excluded as these are not extant for the majority of the skeletons. It can be seen that, in the Dexters, such anomalies are particularly prevalent in the short-leg males but also present in the non-shorts. Though a very small sample, neither the Shorthorn nor the Angus cross Jerseys display any major differences in the general pattern of occurrence, suggesting that these depressions are independent of both breed and chondrodysplasia. The glenoid of the scapula, distal radius and centroquartal are recurrent sites for depressions in the entire sample of both Dexters and Jersey crosses. Since the distal surface of the centroquartal mirrors the proximal surface of the metatarsal, the regular occurrence of depressions on this joint surface could suggest a predisposition for spavin, for example, to develop if the animals were subject to such stimuli as draught work or being tied on hard standing for the winter.

Metapodials and phalanges are extant for Parsnip, Carrot and the Butterbox steer, now considered together for both epiphysial fusion and OC. The epiphysial fusion of the first and second phalanges in Table 3: 16 is as anticipated for the 17

month old Butterbox steer, with fusion completed in the second phalanges and fusion in progress for the first phalanges. The 18 month old steer, Parsnip, shows some delay, with over half the first phalanges unfused. The 28 month old steer, Carrot, appears to be at the same stage of fusion as the 18 month old steer. In addition, the distal epiphyses of the metatarsals in Parsnip and the metacarpals in Carrot remain in two separate halves, rather than fusing into one unit with both condyles. Serjeantson (1986, 229) suggested that fusion of the two condyles of the distal epiphysis of the metapodials occurs at about 5 months old.

Table 3:17 demonstrates that OC depressions in the articular surfaces of the metapodials and phalanges are abundant in Carrot and Parsnip but rare in the Butterbox steer. In fact there are "shadows" on the articular surfaces of the Butterbox steer which suggest that OC depressions had been present but have now fully ossified. The Butterbox steer was reared in more clement conditions on a higher plane of nutrition than either Parsnip or Carrot, hence the observed difference in the rate of skeletal maturation. Conversely, the presence of these depressions on the bones of skeletally more mature cattle may reflect an extended and slow period of skeletal growth, as a response to a low plane of nutrition and inclement environment, resulting in such depressions failing to "fill in" during the final stage of ossification of the joint surface. A mechanism for this may lie in the blood supply to the joint cartilage (Noddle 1999, 1). As discussed in Appendix 3: 1, in extremely cold weather blood supply to the extremities is reduced, which could impact on the joint cartilage of the lower limbs at a critical stage of ossification, resulting in these otherwise juvenile depressions in the articular surfaces being perpetuated in the adult animal. Such a scenario would explain both the consistent presence of these depressions in cattle bred and reared in the Zanfara herd and suggest one possible explanation for the varying rates of incidence observed for archaeological specimens.

Parsnip also exhibits expansion of the proximal medial shaft and articular facet of the metatarsals. Obviously this is not related to draught work but could suggest a predisposition for the development of spavin. Since spavin is associated with cows tied up for the winter in cold climates (discussed in Chapter 4), a similar reduction in blood supply to the joint surfaces could be one factor initiating the development of spavin.

Noddle (1999, 1-3) drew attention to a suite of similar OC lesions in modern pigs, and made the valuable point that these are covered by cartilage in life and so do

not impact on the functioning of the joints. For the pigs, Noddle suggested that modern feeding regimes promoting rapid growth in confined conditions without exercise could be contributory factors. None of these factors apply to the Dexters under consideration, particularly Carrot, nor the Jersey crosses. Noddle further observed that these lesions tend not to be found in mature animals, suggestive that such lesions may be a phase in the growth and ossification of the joint surfaces. There is also the possibility of sex-linkage in cattle. The finding by Persson *et al* (2007) that 97.8% of a group of healthy, performance-tested yearling beef bulls exhibited joint lesions at slaughter indicates that the sample of Dexters and Jersey crosses discussed above is not abnormal and corroborates the proposal that this is a standard phase in the development of the joint surface.

The opportunity arose to test whether a higher plane of nutrition has an impact on obliterating these depressions, as suggested for the Butterbox steer and *contra* Noddle's hypothesis for the pigs. Two Zanfara bulls, Aurelian, a non-short born January 2010, and Karst, a short born February 2010, were purchased by the neighbouring holding and housed in a barn, literally on the other side of the fence to the Zanfara barn, from November 2010 to slaughter at 17 months old in May and June 2011 respectively, comparable to the Butterbox steer. Both were sired by Zanfara Orlando and the dams were mother and daughter. All descended from the same breeding as those in the earlier sample and management until the November had been comparable. The major difference commenced at housing, when they were fed on a higher plane of nutrition than the Zanfara male beef cattle receive, comprising high protein haylage and rolled barley. It can be seen from Table 3:18 that the more complete skeleton of Karst shows a similar distribution of depressions to that observed for the other reference specimens and the extant bones of Aurelian are also comparable. However, like the Butterbox steer, the bones of the lower limbs and feet indicate that some of these depressions were in the process of disappearing at the time of death. Without deliberately looking for them, several of these depressions are so faint they would easily be missed in recording. The pronounced medial *sulcus tendini* seen in the adult bulls is already present in Aurelian and Karst but more pronounced in Karst. This feature was equally prominent in George but not in the other young Dexter males or the Jersey crosses.

The stages of fusion in Table 3: 19 follow the expected pattern apart from the distal tibia and metapodials of Aurelian, which are already fusing. All the phalanges

are at the same stage of fusion in contrast to the variation in fusion stage seen for Parsnip and Carrot, who were both older. While not conclusive, the example of Karst and Aurelian does suggest that, where other variables are comparable, nutritional status and environmental challenge over winter can contribute to either the perseverance or obliteration of OC depressions in older cattle.

Mandibles are extant for 6 of the Dexter males and the MWS are presented in Table 3: 20. The range MWS 17-19 appears to be a good reflection of the age range 15-18 months.

vi. Three year old Dexter

One barren heifer, beefed at 3 years old, is included in this section as being the bridge between the growing young stock and the productive adults. In Hereford cattle, 3 year old females had attained 90% of their mature body weight and 98-9% of mature withers height. Little growth in any dimension occurred after 3 years old (Guilbert & Gregory 1952, 10). The cut off point at 3 years old between growing youngstock and adult cattle seen in the historical records can therefore be linked to a scientifically measurable stage of development.

Dusty was acquired as a weaned heifer. She came bulling in her second year but failed to hold in calf and again the next year when veterinary opinion was sought. Cystic ovaries were diagnosed, which failed to respond to treatment so the heifer was beefed. Similar scenarios must have occurred in the past and explain some of the 2-3 year old cattle represented in analyses of epiphysial fusion and tooth eruption and wear. Such a barren heifer would not achieve the increase in capital value detailed in the Welsh Laws, Table 3: 1, at her first calf bearing nor *teithi* at the second calving. This is an instance where beefing what would otherwise appear to be a valuable animal would be the profitable option.

The epiphysial fusion data for Dusty in Table 3: 21 show a striking contrast with the males who were mostly about half her age. All the epiphyses in the first two groupings have fused. The third group is in the process of fusing, with the proximal tibia yet to commence fusion but the process complete in the proximal ulna. All of these epiphyses were examined closely and there is clear evidence of bone fusion. This grouping gives a very good indication of Dusty's age at death. The vertebral epiphyses appear to be fusing but this is less definite than the limb bones, some of the epiphyses could be prised off and others may only be adhering by adipocere.

The tooth wear, Table 3: 20, also fits the calendar age of Dusty with the early wear stages on premolar 4 and molar 3 fitting in with Silver's (1969) guidelines of 28-36 months for the eruption of premolar 4 and 24-30 months for molar 3.

The OC depressions noted on the articular surfaces of the young males are virtually absent in Dusty, with one example on a carpal.

The measurements of the astragalus and distal humerus in Figures 3:9e and 3:10d show that this heifer lies, as anticipated, at the lower end of the ranges established for the males but that in both instances there are males of a similar size range that might be interpreted as females too. These data and the distal tibia and metapodials will be compared with the other beefed females in Chapter 5.

This section has demonstrated some of the management decisions behind the slaughter of juvenile cattle in a situation where commoditisation of meat is an irrelevant concept. Variation in skeletal maturation rate resulting from high and low planes of nutrition has been demonstrated. In these immature animals, neither epiphysial fusion nor size range are wholly reliable criteria for assigning relative age in the absence of ageing data from teeth. Instead, a cull cohort based on "finish" rather than exact calendar age may be proposed from such data.

The occurrence of OC depressions in the reference specimens has been shown to be independent of breed or chondrodysplasia. Instead, plane of nutrition and ambient temperature at the critical stage of joint ossification are suggested as possible contributory factors for the retention of what appears to be a normal stage of juvenile development in adult animals.

3.4 Archaeological and Recent Case Studies

In archaeological ageing schemes there are two main approaches to presenting data obtained from stages of tooth eruption and wear and epiphysial fusion. One is to present in tabular or graphic form the numbers of specimens found of teeth at specific wear stages or fused: unfused elements, grouped by sequence of eruption or fusion and equated to recent data (Silver 1969) on the age at which these events occur. Although this approach presents relatively raw data, which are therefore available for re-interpretation by other specialists, it has been criticised (O'Connor 2003, 165-6) for anchoring the sequence of development to calendar ages which are of disputed

applicability to archaeological livestock. Provisos are generally given that such ages are merely guidelines, to give an impression of overall herd culling strategies. O'Connor (2003, 178) notes the desirability of presenting reconstructed mean shoulder heights to a general audience but appears to consider that guideline ages are not an equally valid point of public engagement. The possible pitfalls in reconstructing height have been considered for the metrical data in Chapter 2 and are of similar magnitude to the problems encountered in allocating calendar age to stages of skeletal or dental development.

While limb bones are relatively straightforward to record as unfused, fusing or fused, recording of tooth wear can be more complex. As seen in Chapter 2, despite criticisms Grant's (1982) MWS system has been widely adopted. This method records wear for dlp4 but only M1-3 are used to calculate MWS. Calf mandibles broken posterior to dlp4 are disadvantaged, as the state of eruption of M1 cannot be ascertained.

The other broad approach taken is to amalgamate the data from teeth and epiphyses into successive age stages. The system used by Noddle (1983, 94), Appendix 3: 2, is an example. Despite the development of a seemingly objective system, it can be seen that subjective judgement is still required, and an assemblage of sufficient size to allow for "larger than above" comparisons. A further drawback of this approach is that no indication is given for the proportion of the data presented derived from teeth compared to epiphyses, to allow of re-interpretation of the cull pattern. Noddle's age groups are biased towards defining younger animals, with four categories, compared to one undifferentiated category of mature. O'Connor (2003, 160), Appendix 3: 2, proposed a more refined version of this type of scheme but applicable only to mandibles, not epiphysial fusion events. This is more balanced with six younger and five older age groupings but the younger age categories might only span the first three years of life while the older categories might encompass stock aged from three years to early twenties. It can be seen that skeletal age categories are more easily defined for younger animals passing through a regular sequence of developmental events and, in the absence of any correlation to either approximate calendar age or growth and behavioural stages of live animals, beasts that in life were endowed with horns and hormones can be categorised by the zooarchaeologist as "calves", with no chorus of dissent.

It can be seen that neither Noddle's nor O'Connor's proposals for subdividing juvenile cattle can be applied to the Dexter and Jersey reference specimens lacking the heads and feet. This casts doubt on the applicability of such ageing schemes to complex sites consuming beef carcases in addition to beef on the hoof, where mandibles and post-cranial elements may not derive from the same animals.

The zooarchaeological category of "calf", based on all epiphyses unfused, also fails to take account of the allometric growth rate and changing conformation of the live animal. Linear skeletal growth increases faster and matures earlier than thickness growth, (Guilbert and Gregory 1952, 9-10), which impinges on any ratio of length to diaphysial breadth for immature cattle bones. The metapodials show least gain in length, being 85-90% of mature length at birth.

Growth rate is rarely considered for archaeological animals. Morley (1950, 93) observed that at birth a calf is about 7.5% of its dam's weight and that in the first three months, daily live weight gain should be about 0.45kg, rising to 0.6-0.7kg thereafter. Rasby *et al* (1994) recommended similar daily live weight gains for replacement heifers in America, observing that a lower weight gain would impact on the fertility of yearling heifers. Conversely, higher daily weight gains of 1-1.2kg result in the calves laying down fat rather than growing frame. Prior to the Longhorns and Shorthorns of the late 18th century, it is unlikely that archaeological calves would have been fed for the highest daily weight gain, whereas the lowest rate may have been unavoidable due to the vagaries of weather and harvest. It can be appreciated that rates of daily weight gain will impact on skeletal development, as in the case of the Jersey and Guernsey veal calves discussed above. Any proposition to quantify, for example, the development of smooth cortical bone on the diaphyses, needs to be aware that this could be affected by plane of nutrition and season of growth as much as by calendar age. Nevertheless, an unfused bone with smooth cortical surface is patently not from a "calf" in the sense of a neonatal or infant calf.

Recognising the presence of archaeological calf bones can be problematic. Like the stock bull in chapter 2, the infant calf is another constituent of the herd where archaeological evidence may be sparse. Unlike the large and robust bones of adult cattle, calf bones are small and porous and so may not survive in soils where the burial conditions are less than benign. The small size of calf bones means they are subject to the recovery bias during hand excavation that affects all smaller elements and species. Faunal assemblages from older excavations, predating the routine sieving

of bulk soil samples, are more likely to have under-representation of calf bones. Even if preservation and recovery are good, there remains the identification of calf bones. Amorosi (1989) recognised this could be a problem. Generally the mandible and frontal bones survive well and are readily recognised. Other elements can be damaged by canid gnawing, besides poor preservation, rendering them unrecognisable. Such bones can be inadvertently relegated to a general "sheep-size" category.

Where calf bones do survive, interesting speculation on calf slaughter can be generated. Vigne and Helmer (2007, 26-32) observe and discuss the Neolithic evidence for high frequencies of bones from very young calves and conclude that "the frequency of the phenomenon leads to a consideration of other explanations, especially of a technical nature". That the technical nature of the explanation could be the provision of rennet for the production of curds and cheese is not, however, explicitly discussed, despite the assertion that "the exploitation of cow's milk should never require any slaughtering peak of newborn calves". The more recent historical information can therefore suggest a hypothesis to interpret a prehistoric pattern.

There is plentiful evidence from both finds of bog butter casks (Earwood 1993) and the Norse sagas, for example Njal's Saga (Magnusson & Palsson 1960, 122-3), for the importance of butter, as well as cheese. Since butter is made by churning cream, there would be no necessity to kill the calf to obtain rennet if butter was the primary dairy product. This suggestion would allow the calf to be reared on skim milk, while the humans had the high calorie butter.

The Neolithic data discussed by Vigne and Helmer (2007, 29-32) also include evidence for a peak cull of older calves, roughly 6-12 months old, interpreted as post-lactation slaughtering of calves whose dams had no milk let-down response in the absence of the calf. These weaned calves could possibly represent a butter-based dairy strategy, though concurrent milking and suckling throughout the lactation was practised in Scotland into the early 19th century (Grant 1995, 214). Neither interpretation fits the known facts for cattle in this age group in the reference collection, above.

A selection of case studies of calf bones from specific sites will now be considered, in chronological order.

Case Study one: Ulkestrup Lyng, Neolithic Europe and Grimes Graves

Finds of calf bones from prehistoric sites are rare, due to the adverse effect of taphonomic factors on such fragile bones being enhanced by the age of the deposits. Two sites with exceptional preservational conditions have produced finds of calf bones. These are Ulkestrup Lyng (Richter 1982), a Mesolithic site in Denmark with aurochs calves and Grimes Graves (Legge 1992), a Bronze Age site in England with domestic calves. Despite the difference in age and location, there are similarities between the finds. Calves are represented by mandibles on both sites and the age at death, estimated from tooth development and wear, is suggested to be 1-3 months old for both sites. The interpretations of these superficially similar finds are radically different. Ulkestrup Lyng is seen as a hunter-gatherer site occupied from April to late summer, with the aurochs calf bones being one of the seasonal indicators. At the time of publication (Legge 1981), the interpretation of the Grimes Graves calf bones as evidence for settled prehistoric dairy-based cattle management was revolutionary and provoked controversy, for example McCormick (1992). The concept is now mainstream thinking and projected back into the Neolithic. Vigne and Helmer (2007, 29) summarise data from Neolithic sites in France, the Balkans and Italy which show peaks of killing very young calves, believed to be less than a month old, though Vigne and Helmer (2007, 33) admit that accurate data on age at death of these calves is lacking.

No-one appears to have yet suggested taking the concept of spring-born calf slaughter as evidence for dairy exploitation further back in time to suggest that the Ulkestrup Lyng calf mandibles could equally represent milking of aurochs cows. However, what is clear is that the slaughter of calves aged about 2-3 months old, discussed for historical periods, is of venerable antiquity. This may indicate an indissoluble link to cattle biology, irrespective of whether the cattle were wild or domestic. The study of calf behaviour in Italian Maremmana range cattle (Tenucci & Vitale 1991) showed that the cow/calf bond weakened when the calf was about 50 days old but associations with other calves strengthened. This may have provided a natural window of opportunity either to hunt wild calves or to cull domestic calves without invoking the extreme aggressive reaction shown by a cow when an infant calf is threatened or killed (Galton 1907, 51-2). Veal, defined as a young sucking calf, has clearly been appreciated for many thousands of years as a spring delicacy. A consequence of Mesolithic hunters killing young sucking aurochs calves would have

been the discovery of curds in the omasum, or stomach bag. The connection between milk warm from the cow entering the warm stomach of the calf and becoming curds would therefore have been common knowledge prior to domestication of cattle.

An unintended side effect of the slaughtering of both aurochs and domestic calves would have been enhanced fertility of the dam at the next conception. Mukasa-Mugerwa (1989) has summarised the literature on lactational anoestrus and the effect of weaning. Removing the calf at less than 3 months old can increase the pregnancy rate, reduce the post-partum anoestrus period and increase the daily weight gain of the cow. In domestic taurine cattle, temporary weaning of calves at 40-50 days post-partum can induce oestrus in the cow. Empirical observation could have led to calf slaughter as a technique to improve conception rates and possibly induce aseasonal breeding in cows. Vigne and Helmer (2007, 32) consider that Neolithic farmers "deliberately killed their newborn calves for a special reason", without suggesting any special reasons in explanation. Manipulation of the breeding cycle of the dam is therefore one possibility. However, perhaps more probable, may be the simple relationship between the rennet obtained from the stomach bag of the infant calf and cheesemaking. This simple technology merely expanded on the hunters' exploitation of wild calves to domestic cattle. Since Greenfield (2010, 33) argues that the Secondary Products Revolution model (Sherratt 1981) is a shift in exploitation emphasis, then cattle dairying with associated calf slaughter for curd production in the Neolithic was truly a revolution in emphasis from the casual, seasonal slaughter of aurochs calves in the Mesolithic. The killing of sucking calves and concomitant milking of cows at Grimes Graves may therefore be a centuries old pattern of herding, originally deriving from a hunting strategy. However, identification of such cattle exploitation is wholly dependent on survival of calf bones, particularly mandibles.

Calf slaughter or weaning at about 50 days after birth is therefore attuned to manipulating the reproductive and behavioural biology of cattle and would appear to have been observed and understood by cattle hunters and herders over thousands of years and the knowledge transmitted into the historical past.

Case Study two: Welsh Row, Nantwich

This site was a 2nd-4th century AD Romano-British township near Nantwich in Cheshire (Archaeological Services 2007b). The faunal remains were recovered from the fills of two massive brine cisterns. The waterlogged preservation of the

bones within these features was generally excellent, leading to the recovery of bones from very young calves from four contexts. The most complete find comprised the majority of the principal limb bones, the mandibles and some ribs and vertebrae of an infant calf. This was almost certainly deposited as a complete articulated body and the missing elements have merely been lost in the mud. Measurements of the limb bones at first suggested this was a foetal calf of about 240 days gestation, using data from modern continental cattle (Prummel 1989, 74). However, these bones were visually similar to those from a full term still born Dexter bull calf in the author's reference collection and the measurements of this archaeological find and the Dexter are practically identical, Table 3: 22. This suggested that the archaeological find represents a neonatal calf from cattle more comparable in size to the Dexter. However, it should be noted that the archaeological specimen, though the same length as the Dexter, is more gracile in build. Plate 3: 9 compares the humerus from this archaeological calf with the modern Dexter and a still born continental cross bred calf. Further comparison of this specimen and the Dexters was then made with the larger sample of Anglo-Saxon calf bones from Lindisfarne.

Case Study three: Lindisfarne

Scott (2000) studied the faunal remains from Green Shiel, an Anglo-Saxon rural settlement on Lindisfarne. The calcareous sand covering the site has created a favourable depositional environment for the survival of fragile bones. The vast majority of the bones recovered were from juvenile cattle, with the preponderance of calf metapodials and phalanges suggesting that the site was a vellum processing workshop associated with the Anglo-Saxon monastery. It is suggested that skins with the feet attached were procured. Finds of articulated adult cattle skeletons were also made.

Calf mandibles were also present, though less abundant than the metapodials. Scott (2000, 76-77) compared several methods of estimating age at death from the mandibles and the results were in agreement that about a third of the mandibles on the site derive from calves slaughtered between birth and one month old, with approximately a quarter from calves aged up to 6-8 months old. Scott (2000, 22) illustrates two calf metatarsals with their associated phalanges and epiphyses. It is clear that the distal epiphyses of the metatarsals are two separate entities. Serjeantson (1986, 229) observed that this was the case in a reference specimen aged 3 months but

in a specimen aged 5 months the two condyles had fused into one epiphysis. The mandibles and metatarsals from Green Shiel therefore concur with the procurement of calves less than five months old, possibly skins with heads as well as feet attached.

Metrical data from the Lindisfarne calf bones were considered in Section 2, discussing the applicability of standard factors for estimating gestational age from limb bone length, but merit further consideration. The metapodials of four adult female cattle skeletons could be measured. The metacarpals indicate withers heights of 1.0m, 1.01m, 1.06m and 1.07m while the estimates from the metatarsals are 1.03m, 1.04m, 1.07m and 1.09m. There is an obvious discrepancy between the results from fore and hind limb but it is clear that these were very small cows, comparable in height to modern Dexters. The size of the calf bones should therefore reflect the size of the adults.

Figure 3: 11 shows, in effect, half of a normal bell curve distribution on the left hand side and a more fragmented spread on the right hand side. This might suggest culling of the smaller infant calves from a normal range of birth sizes and a smaller spread of older calves. However, comparison with the distribution of births by month for the Zanfara herd in Figure 3: 3 suggests another possibility. The left hand curve could indicate a seasonal cull of calves born within a relatively short space of time and forming a "job lot" of skins, with the larger, and older, calves indicating fewer births over a longer time span and a lag in getting a sufficient cohort of calves together for delivery of the skins to be viable. The plot of heifer birth weights from the Knotting Dexter herd, Figure 3: 5i, approaches a mirror image of the Lindisfarne graph. Leg bone length and birth weight are not necessarily correlated but this does show that an asymmetric distribution can occur in new-born calves.
Figure 3:11b compares the Romano-British specimen from Nantwich, above, together with the modern still born Dexters and the calf metatarsals from Lindisfarne. The Dexters and Nantwich specimen fall within the lower end of the range for Lindisfarne, suggesting that the comparable archaeological calves may also have been perinatal fatalities.

Case Study four: Emden, Germany

Jessica Grimm very kindly provided data on the finds of calf bones from medieval Emden, prior to online publication (Grimm 2010). Two excavations, Rosenstrasse and Kirschstrasse, with contexts spanning the 10th– 16th centuries,

provided all but one of the 59 calf limb bones, categorised by Grimm as "foetal" in Table 3: 23, according to the criteria of Habermehl (1975). While the calves estimated at 270-280 days gestation may well have been full-term, Grimm's interpretation of the remaining bones as foetal calves otherwise appears entirely reasonable.

Figures 3: 12 a-e plot the greatest lengths of these possibly foetal calf bones against the known full-term, stillborn Dexter calves. In every case, it can be seen that, while there is overlap with the Dexters, the Emden calf bones are generally longer. The Dexters include non-short calves, so the disparity is not simply dwarf versus normal. Gundrada is also included for comparison, a non-short heifer who displayed normal growth until a month old, when she was taken ill. Only the femur of Gundrada falls beyond the range of the Emden examples.

This example suggests that caution should be used in the application of data from modern foetal calves to archaeological finds. The Simmental breed might be thought to be more comparable to medieval German cattle than to British breeds, but these data suggest this might not be the case. Using measurements in isolation, as in this example, might perpetuate misleading interpretations. When using metrical data from infant calf bones, it can be seen that these should be placed in the context of metrical data for the adult female cattle on the same archaeological sites. Grimm (2010, 37 & 71) provides Greatest Length measurements for the adult cattle metapodials from the Rosenstrasse and Kirschstrasse excavations. From these, estimated withers heights have been calculated using the mean of Zalkin's (1960, 126) factors, as discussed in Chapter 2. A mean height of 1.22m with a standard deviation of 0.06m is indicated, though this obviously includes both sexes. Figure 3: 13 shows that there is a tail of taller, possibly male, cattle and therefore the female cattle may fall at the lower end of the range, spanning 1.12-1.24m. The majority of the Emden cattle were below the Simmental average cow height of 1.3m, and so their new-born calves might be expected to be proportionally smaller too. The smaller Emden cattle were comparable in size to the larger non-short Dexters, so it is possible that all these calf bones could represent full-term still births and post-natal mortalities. Since Gundrada's bones mostly fall within the Emden range, it is also possible to suggest that all the Emden calf bones could represent consumption of veal. Beeton (1861 facs. 402) observed that "the taste for very young veal has entirely gone out", though it still obtained in other countries. However, in the mid 20th century, surplus

calves from British dairy herds were still sold within a few days of birth for potted veal (Morley 1950, 98).

These two differing interpretations of the Emden calf bone measurements could lead to divergent reconstructions both of animal health and husbandry and of foodways. Once one interpretation by a reputable specialist appears in print, the "Chinese whispers" effect in subsequent overviews of medieval economics would become established as received wisdom. This example reinforces the necessity of re-visiting raw data before embarking on works of synthesis and the indispensable nature of a reference collection from animals comparable in size to the archaeological finds.

Case Study five: Monkseaton Chapel Lane

Foetal calf bones are rarely encountered archaeologically. This is an area where, with hindsight, the author may have encountered specimens but without recognising them for what they might have been, other than infant calves. Amongst the bones of predominantly mature female cattle, which comprise the bulk of the hand-recovered faunal remains from many Romano-British settlements such as forts and towns, are occasional finds of elements from very young calves. Some of these could well be foetal. The collection of foetuses from abattoirs slaughtering cull dairy cows has been the primary source of modern data for establishing the development of the foetal skeleton (Prummel 1987, 25). However, the deliberate sacrifice of pregnant cows was one of the spring rites of the Roman religious calendar (Henig 1984, 29).

The find of a medieval cow burial at Monkseaton Chapel Lane by Archaeological Services, Durham University in 2006 is therefore of considerable interest as it was observed during excavation that there were small bones, presumed to be a calf, in the abdominal region, Figure 3: 10. The expectation was that this would be an example of dystocia (Schwabe & Hall 1989, 636), resulting in the death of the dam and unborn calf. The cow was adult but the fusion lines are still clear on the proximal humeri and distal femora, suggesting an age at death about 4 years old (Silver 1969). The permanent dentition is present and in wear, MWS 43. A withers height of 1.11m was estimated from one complete metacarpal, using the average of Zalkin's factors (Driesch & Boessneck 1974, 336). Examination of the calf bones indicated that this was not a full-term foetus. While the bones are fragile and have been damaged during excavation from the clayey fill of the burial, one radius, metacarpal, tibia and metatarsal are measurable, Table 3: 24. It can be seen that these

bones are far smaller than even the smallest full-term Dexter calf, or the proposed foetal calf bones from Emden. The radius, metacarpal and tibia fall within the range for 210-220 days gestation given by Prummel (1989, 74), while the metatarsal suggests 220-230 days gestation. The diaphyses of metacarpals 3 and 4 are unfused, while the process has commenced in the metatarsals. Fusion of the diaphyses should occur between 200-210 days of gestation (Prummel 1987, 26), a possibly more reliable indicator of gestation than bone lengths. Timing of these events is rendered less precise by the veterinary use of radiographs compared to the dry bones of the archaeologist. It is nevertheless apparent that the cow died when somewhere between six and seven months in calf.

Case Study six: Durham Cathedral Precinct

The cathedral precinct at Durham provides a rare opportunity to compare cookery instructions with contemporary archaeological finds. John Thacker was cook to the Dean and Chapter of Durham Cathedral from 1739 to 1758 (Day 2004, *vii*). The cookery book that Thacker published in 1758 is unusual in that it was originally written as a practical manual, in monthly instalments, for the students attending Thacker's school of cookery. Thacker promoted this book by the observation that other contemporary works "are far short of being generally useful, especially in these Northern Parts, where the Seasons occasion such Alterations in the Bills of Fare for each Month, from those calculated for the Southern Parts" (Day 2004, *xxxi*). A study of Thacker's recipes and Bills of Fare should therefore give an indication of the availability of veal in Durham in the mid 18th century. It can be seen from Table 3: 25 that Thacker provides most recipes for veal in the first five months of the year. Only for June does no recipe require veal, though it appears on the Bill of Fare for this month. Conversely veal does not feature on the Bills of Fare for August and December but appears in recipes for these months. Much of this disparity merely reflects the regular consumption of straightforward dishes, such as veal collops, which only required instructions for preparation once, early in the cycle of Thacker's work. Despite Thacker's acknowledgement that the seasonal availability of ingredients in the North of England differed from the South, it is clear that veal was supplied all year round. This compares with William Mountford's household in Warwickshire, that was supplied with veal in almost every week of the accounting year 1433-4 (Dyer 2006, 201). The frequency with which veal appeared on the table is illustrated by the

Bills of Fare for the Residency of the Dean 29th September-19th October 1753 in Table 3: 26. In this three week cycle, there were only two days on which veal was not served. Collops were the most frequent dish, appearing on seven of the 21 days.

O'Connor (2008b, 90) challenged the definition of what the Mountford household called veal, on the grounds that cattle at that time were "highly unlikely" to have been breeding year-round, and assumes "veal" to have encompassed all young stock to "near-yearling" beef. Thacker (Day 2004, 254) is quite explicit that the veal in October for a *Chine à la Smithergall* should be the "smallest and whitest you can get". This is clearly very young, milk-fed white veal. The abundance of veal consumed in October for the Residency, and the description of small and white veal in the same month, at the very least suggests that autumn calving was unremarkable. The assumption is generally made that these veal calves would be "surplus bull-calves" from "large herds of dairy cows maintained to adulthood" (Sykes 2006, 59). However, where Thacker is specific, the recommendation is always for veal from heifer calves. For example, February has brown collops from a leg of a well-fed calf dished with the "udder of the veal" stuffed with force meat. Both the leg and breast could be also served "white", indicating the use of white veal (Day 2004, 32-3). In August a fillet of veal of a quey (heifer) calf is specified (Day 2004, 220-1). Heifer veal was therefore readily available in Durham, six months apart, in early spring and autumn. Thacker was writing at a time when the local dairy cow much resembled the statue of the Dun Cow on the cathedral (Gidney 2009; see Chapter 4). While of good conformation for the pail, the adult build of such cows would not produce a good return of beef for the inputs required to rear stock not needed for dairy herd replacements. Plump, milk-fed surplus heifer calves may have commanded a better financial return as veal, given the constant demand, in this instance, from the cathedral close. A similar pattern of heifer calf slaughter for veal might be envisaged wherever a high-status establishment created a demand for the product.

Perusal of other 17th, 18th and 19th century cookery books demonstrates that Thacker was not alone in using heifer calf veal, nor in finding veal readily available year round. The anonymous author "W.M." of The Compleat Cook, first published in 1655, states that "if the leg of veal be of a Cow Calf, the udder will be good instead of beef suet" for making balls of veal (1983, 38). Eliza Smith (1758 facs., 4) observes that in choosing veal " the flesh of a bull-calf is firmer grained and redder than that of a cow-calf, and the fat more curdled", advice also given by Hannah Glasse (1747

facs., 161). Elizabeth Raffald (1782 facs., 100) specifies a "fillet of a cow calf" in the instructions to stew a fillet of veal. John Trusler (1791, 99) states that "large, over-grown veal is never good" and that "the leg of a cow-calf is preferable to that of the bull-calf; the former may be known by the udder, and the softness of the skirt; and, the fat of a bull-calf, is harder and curdled. Veal, to be delicate, should always look white in the flesh, like rabbit or chicken". Elizabeth Ellet repeated similar advice in America in 1857: "the flesh of the bull-calf is of a brighter colour than that of the cow-calf. The fillet of the latter is generally preferred on account of the udder" (www.chestofbooks.com file://F:\3Calf\Marketingveal.htm).

Elizabeth Raffald worked in Cheshire, still known as a "dairy" county, and veal appears in every month of the year in her monthly lists of food in season (1782 facs., 370-383). In Eliza Smith's specimen Bills of Fare, veal is only absent in June and August (1758 facs.,). No season with lack of availability is given for any butcher's meat by Hannah Glasse (1747 facs., 160-161). Isabella Beeton (1861 facs., 401-4) observed that veal could be obtained at all seasons but usually appeared in quantity at the beginning of February in London, being about eight weeks old. The main London veal season ended in November.

Norman Emery, archaeologist to Durham Cathedral, has examined many post-medieval midden deposits from the cathedral precincts. Although the faunal assemblages from these interventions are small, calf bones, categorised by this author as "veal calves", have been encountered regularly. No. 11, The College produced particularly well preserved calf bones. These include longitudinally split halves of one metacarpal and two metatarsals. This is indicative of culinary usage, though Thacker only mentions "take out the bones" for a Florentine of calves' feet in January (Day 2004, 12). Table 3: 27 compares the lengths of these "veal calf" bones with those from the older Dexter and Jersey calves. The Durham veal calf bones are slightly shorter than those of Tinkerbel, Plate 3: 11, who was about ten weeks old at death. It is appreciated that this is a very small sample. However, only the Jersey, aged four or six months old, compares with the range of 133-164 mm Greatest Length, established for 18th century calf metacarpals from Kingston (Serjeantson *et al* 1986, 229), which are thought to derive from animals aged *circa* 3-5 months old. Recipes requiring the use of calves' feet for their gelatinous properties abound in the period cookery books. The very fact that the Kingston calf metapodials were discarded intact, with no

evidence for culinary use (Serjeantson *et al* 1986, 231), suggests that calves of this age were not considered as "veal".

The site at No 11, The College produced one calf mandible. A further complete mandible, a damaged one and a loose dlp4 were recovered from the re-deposited ash midden used as hardcore in the construction of Prebend's Bridge, and therefore pre-dating the reconstruction of the bridge in 1772. Table 3: 28 gives TWS, after Grant (1982), for dlp4 and M1, in comparison with the modern calves. The Durham mandibles group at one developmental stage, falling between Gundrada, aged c. 6 weeks and Tinkerbel, aged c. 10 weeks. It would appear that the age of 8 weeks for 19th century veal calves given by Beeton is also plausible for 18th century veal calves in Durham.

As to the vexed question of whether these calves were male or female, there is one, admittedly tenuous, line of evidence. Calf frontal bones, from the calf's head dishes ubiquitous in the cookery books, have been recovered from several of the sites investigated in the environs of Durham cathedral. The example in Plates 3: 12a-c from No 11, The College is typical, comparable in size to a new-born Dexter bull calf and exhibits only a slight, roughened, protuberance to indicate the position of the horn bud. Plates 3: 13a-c show a bull calf, Aurelian, aged 8 weeks, in comparison with a heifer calf, Tittlemouse, aged 7 weeks. The horn buds on the bull calf are already prominent, while there is only a curl of hair on the heifer's head to show where the horn buds will appear. Incidentally, the heifer is, at this age, larger and plumper than the bull calf, so would make a superior veal carcase.

3.5 Discussion

What has become apparent from this study is the necessity of a good comparative collection of calf skeletons aged under a year old, to subdivide this blanket archaeological age group. While foetal ageing is of widespread interest to veterinarians, little comparable modern interest appears to have been shown in post-partum calf skeletal development. Given the high juvenile mortality in the Chillingham herd, this could be an appropriate source for the collection of such data for comparison with archaeological finds.

The archaeological interpretation that veal calves would be exclusively bull calves is not supported by either post-medieval culinary texts or medieval values for

male and female youngstock. Rather, the recorded killing of all first born calves, or all calves born at specific times of year, would be anticipated to yield veal from both bull and heifer calves.

Although the widespread culling of infant calves, identified in the archaeological record from the 15th century onwards might be expected to exert a selective pressure in favour of "improvement", this may not in fact have been the case. Selection appears to have been a total cull of all calves born at specific times of year, without regard to the merit of either the calf, dam or sire. This may well have led to inadvertent selection in favour of autumn and winter calving, as these were the calves that were reared, but not to an overall "improvement" in other traits, deemed desirable by 18th century and later breeders.

A range of possible answers have been discussed in answer to the question posed by Mulville (*et al* 2005, 173) of "why do calves die", beyond the simple equation of calf slaughter as a means of liberating milk for human consumption. Such answers include the fact that the calf itself was of minimal value in comparison with the value of the dam's milk that would be needed to rear it (Fitzherbert 1534, 41-2). Spring born calves, particularly in marginal environments such as the Western Isles of Scotland studied by Mulville, could be at a higher risk of mortality caused both by adverse weather and disease. Deliberate slaughter would therefore preclude potential loss from such causes and yield a usable carcase to bridge the "hungry gap" for the cow keepers. This in turn feeds into to the demand for small, white veal at the Easter feast following the Lenten fast in Christian communities. Where dairy products were of prime importance, killing the calf would be one way of stimulating the dam's return to oestrus, thereby increasing the probability of pregnancy and a lactation the following year. The preferential slaughter of spring born heifer calves would also produce the best quality calf skins for both tanning and vellum manufacture. Whether calf slaughter generated a cash income or paid a tax in kind, spring slaughter of calves would produce a return from the herd at a lean time of year, rather than the expenditure of limited resources of milk, fodder and pasture needed for calf rearing.

The common notion that most heifer calves would be reared and most bull calves killed can be seen to be flawed on several grounds. Where agricultural production was primarily arable, then the male calf as a potential working ox would be reared not the heifer. Even in upland areas where the vaccary was of fiscal importance, only enough heifer calves needed to be raised to replace culls from the

adult herd. For example, estimating a 12 year life expectancy and a herd of 12 cows, only one heifer a year of a possible six born would be needed as a replacement.

Examination of the birth weights and limb bone lengths of Dexter calves suggest that the application of data from modern commercial breeds could produce flawed interpretations of archaeological finds from animals more akin in size to the Dexter. The proxy data of calf birth weights indicate reduced size variation within individual herds compared to the overall dataset. This is of potential interest for the interpretation of size variation in archaeological assemblages and hypotheses linking elevated occurrence of non-metrical traits with restricted breeding pools.The incidence of OC in the beefed Dexter and Jersey cross males suggests that neither heredity nor chondrodysplasia in the short-leg animals are principle causes of this disorder. Rather, these data tend to confirm the suggestion of Ytrehus (*et al* 2007, 429) that failure of blood supply to growth cartilage is more probable. In the example of the Zanfara herd, this may be attributed to outwintering growing young stock on a low plane of nutrition.

While much zooarchaeological endeavour has been expended on refining the age classification of skeletally immature cattle bones, the reference specimens discussed have confirmed O'Connor's (2003, 165) observation that environmental insults impact on rates of epiphysial fusion. However, the data from this reference collection suggest that, at the level of an archaeological assemblage, such anomalies in maturation rate balance out to give an overview of culling policy, particularly in the absence of complementary dental data. The historical data suggest that the important group was the year cohort, not the exact calendar age of the individual, rendering a "fuzzy" approach to cull cohorts defined by epiphysial fusion in keeping with the attitudes of the original cattle herders.

Chapter 4. The Cow: Dairy

The next two chapters consider the cow. The calf-rearing cow and the end use of the cow as beef are considered in Chapter 5 while here the focus is upon the cow primarily as a dairy animal, where the food products obtained from the milk are the principle return from the herd. Today, there is a clear dichotomy between the conformation of dairy and beef breeds and the ideal dairy cow shows selection for a particular type of build, referred to as "gracile". This frame does not require heavy feeding, has no tendency to lay on flesh, and is characterised by light and fine bones, thin and soft skin and a general air of refinement. In addition, the barrel should be round and deep, the mammary system well developed and the pelvis long and wide to facilitate parturition (Morley 1950, 14-7). The general outline is known as the "dairy wedge", or triangle, with a level back, or topline, and the underside rising slightly from the udder to a light brisket and dewlap. The Dexter cow Grinstead Trixie 8th, Plate 4:1, is an example of the dairy phenotype within this dual-purpose breed. In purely archaeological terms, the light and fine, or gracile, bones might be the primary evidence for the identification of specialised dairy-type cows.

4.1 Historical Information

Although Chapter 3 demonstrated that calf cull patterns may indicate dairy exploitation from the Neolithic, much of the surviving literary and artistic sources for the specialist vaccary, or dairy, herd dates to the medieval period. From these it is implied that households at all social levels would have made and consumed their own dairy produce, though surviving written evidence for medieval dairies and their equipment generally relates to the middle and upper ranks of society, (Hellier and Moorhouse 1980, 1). Insights into the importance of such dairy produce to the lower echelons of society may be gained from the use of literary stereotypes. The most common of these is the poor widow, epitomised by Chaucer in the Nun’s Priest’s Tale (Coghill and Tolkien 1959, 65). This widow and her two daughters made a living from three sows, three cows and one sheep and dined on bread and milk. The importance of the three cows is further emphasised by the appellation of the widow as being, in effect, a dairy woman. While this widow is fictional, references to widows among the late 12th century customary tenants of the Bishop of Durham in Boldon

Book (Austin 1982) indicate the size of the holding needed to support this number of livestock and the frequency of widowhood among the tenantry. Four settlements out of 105 have specific mentions of widows while a further two settlements list holdings of women of uncertain marital status. These widows' holdings range from two bovates, the standard villein holding in Boldon as the type settlement for tenancies, to merely a toft. All but two women held rent free by alms of the Bishop and there is no evidence in Boldon Book of widows being coerced into marriage to ensure arable cultivation (Dyer 2002, 157).

Such widows would be dependent on the availability of common pasture for their livestock and became symbolic of the hardship ensuing on the post-medieval introduction of rabbit warrens to commons by manorial lords and 18th century enclosure (Williamson 2007, 163-4). Even at the height of the age of improvement and enclosure, the value of a cow for the support of elderly childless women was recognised by the Earl of Winchelsea as a great saving on the parish poor rate (Young 1796, 232). This association between the elderly spinster and the old cow was still to be found in the mid 20th century (Smith and Wilcox 1951, 139) and the historical poor widow with few, or only one cow, is one possible explanation for the archaeological presence of teeth from aged cattle (Jones & Sadler 2004, 2012), which otherwise appear contrary to the standard advice in the medieval treatises to cull older cattle before age-related degeneration set in (Oschinsky 1971, 285).

This interdependence between woman and cow could lead to a bond unimagined by contemporary men, who viewed cows as merely so much cash on the hoof. These contrasting attitudes are exemplified in the traditional Scottish story "a Cateran in Love", where the old childless widow hangs on to the neck of her one cow, driven off in a cattle raid. When discovered, the raider was astonished that the woman was emotionally attached to the cow, to the extent of giving it the Christian name Morag, and viewed it, though valuable, as more than just a supply of food (McHardy 2004, 246-7). Fabre-Vassas (1997, 85) points out that giving domestic livestock Christian names, rather than descriptive names, has implications of association with Christian baptism and the exclusion of such animals from the human food chain.

Rather than reivers, recent threats to cows have included the post-BSE OTMS, the subsequent OCDS and the Foot and Mouth contiguous culls. Older cows can become iconic symbols of survival of such trials, for example in the Zanfara herd, Clarissa, aged 19 in 2013, whose value as a living reminder of resistance to the

continuing pressure to cull far outweighs any residual capital value, while the annual calf provides a good return on the original investment in the cow. Such aged cows develop personalities distinct from their herd mates. Clarissa is no exception, actively initiating grooming sessions. Other examples of such special elderly cows will be discussed in Section 3 as examples of the lifetime productivity of such old cows.

Chaucer's poor widow with three cows but no calves would appear to have had the capacity to sell surplus dairy produce. Langland's equally fictional Piers the Plowman is described as having a cow and calf but also green cheeses, curds and cream (Skeat 1965, 77). Further literary examples of one cow supporting a family are also found in the 16th century, Best (1986, xlvi) cites the variety of "white meats", or dairy produce, that might be obtained for the sustenance of a Tudor family and in the Border Ballad "Dick o' the Cow", the best milk cow supports a family with three children (Scott 1931). Cobbett (1822 facs., 96) in the 19th century was extolling the virtues of the house cow for the support of a labourer's family, though specifying for the purpose that "a cow of the smallest sort common in England is, on every account, the best" (1822 facs., 81).

i. Hendre and Hafod, Shielings and Vaccaries

In upland areas, hendre and hafod, shielings and vaccaries were all systems of sending milking cows away from the homestead for summer. In Wales, the local availability of cattle in the neighbourhood of lowland castles, such as Dryslwyn (Gidney & Caple 2007), is likely to have been seasonally variable with the indigenous system of transhumance of livestock in the summer to the mountain hafod from the hendre or permanent valley farmstead (Ryder 1983, 498). This system released the low land for hay meadow for winter fodder, and, unwittingly, may have enhanced the fertility of the cows (Dahl & Hjort 1976, 34) and reduced mortality from parasite burdens. The fresh grass of the mountain pasture was converted into butter and cheese. Despite increasing transport of fresh milk by railway from the mid 19th century (Robertson 1994), this seasonality of mountain dairy cheese production continued into the 20th century, with the first cheeses made in spring with the arrival of the cuckoo (Minwel Tibbott 1995-6, 73). The cheese making season was from April to September in England (Trow-Smith 1957, 121) and Woolgar (2006, 95) points out that dairy foods were therefore available for consumption during the months when little, or none, was produced.

The value of milking cows to medieval English landowners, whether secular or religious, is evidenced by the establishment of seasonal vaccaries, milking units exploiting summer grazing. The Boldon Book (Austin 1982) gives an indication of how such vaccaries might have been stocked in the later 12th century. These are the cows rendered to the Bishop of Durham by entire townships, phrased as "tota villa reddit …. et i vaccam de metride", translated by Austin (1982 14-15) as "the whole township yields ….. and one cow for metreth". Austin (1982, 84) discusses the possible interpretations of metreth as equivalent to the Welsh *treth Calan Mai*, or tribute of the Kalends of May, and the Lancashire *beltancu*, or Beltane cow, given on May 1st. While Austin is not convinced by these comparisons, the render of cows in early lactation in May would make a great deal of practical sense for stocking the vaccaries farmed in hand by the Bishop, such as that at Lanchester (Austin 1982, 44-5). Twenty-seven settlements rendered the equivalent of 32 cows annually. Two of these cows were made up of "half cows" from four townships. There is no indication of how these "half" cows were given in practice, for example one every other year or alternate years between pairs of settlements, nor of how the inhabitants of the townships selected the cow for metreth between themselves. Regardless, the Bishop and his auditors could plan for an annual rolling programme of at least 30 replacement vaccary cows. Boldon Book is explicitly recording "new" villein tenure, with many customary dues commuted to cash payments but only at Whickham is it recorded that the cow for metreth was no longer provided as this was subsumed within the cash payment for the lease of the entire manor and its stock.

By the 14th century, the cows were commonly leased to dairy workers for the season for a cash sum. In this sense, the vaccary cows were a specialised dairy unit and represented the landlord's capital investment in the cattle producing a cash return. The treatise *Husbandry* explicitly states that the money received for farming out the milk yield of the cow will pay for the tithe, while the cow and calf remain the property of the owner (Oschinsky 1971, 427).

The surviving documentary evidence from Barnard Castle gives a brief glimpse of this system at work for the accounting years 1324-5 and 1325-6 (Austin 2007, 105), in the aftermath of the famine and agrarian crisis of 1315-1322 (Kershaw 1973). The cattle were divided into the leased herd consisting of 129 cows, of which 52 were in milk, then the following year 132 cows, of which 68 were in milk at the time of the accounting. In the second year only, the desmesne herd is listed in full,

including 77 cows and 18 barren cows compared to 84 adult males. The majority of the calves from the desmesne herd appear to have been reared, compared to only nine calves noted from the leased herd. The desmesne herd appears to have supplied sufficient dairy produce for the castle household as well. Two systems of management were therefore applied to cattle within single ownership. Selection for the leased herd may have been based on time of calving to optimise milk yield, and concomitant cash income from the vaccaries, rather than any dichotomy into modern notions of dairy or beef conformation. The loss of the leased herd in 1308, described below, strongly suggests that subsequent replacements would have been bred from the desmesne herd. This highlights the multipurpose nature of these cattle and restricts what would have been possible in the way of "improvement", even had this been a contemporary concept. Extremes of dairy or beef type would not have been suitable for the proposed migration between desmesne and leased herds, and the over-arching necessity to breed level teams for the yoke would have imposed an overall standard on the cows breeding replacement oxen.

The value of the leased herd and the income to the lordship from the vaccaries is shown by the raid on Teesdale in 1308 by officials of the bishop of Durham, with the loss of livestock worth £1,000 (Austin 2007, 71). Since the income from the lordship stood at £333 19s 1d in 1306 (Austin 2007, 69), it can be seen that the overall loss was the equivalent of three years income for the whole lordship. This episode strongly suggests that the vaccary cows were in some respect the equivalent of the Irish creaght (Lucas 1989, 68-124) in feeding and financing the martial element of a lordship. The pre-emptive strike by the bishop of Durham targeted the financial and symbolic aspects of lordship in a way that diminished the possibility of retribution. Similar tactics of destroying the creaghts, to erode the fiscal and military capability of the Irish, were employed by the English from the 16th century onwards.

This was only part of more general woes of the 14th century, murrain of livestock and crop failures were compounded by increased Scottish raids and then followed by the Black Death. It is unlikely that livestock "improvement" could have been a consideration at this time, when merely keeping man and beast alive was a struggle. By 1317-18, the lordship of Barnard Castle was only valued at £275 per annum (Austin 2007, 71) and had recovered to merely £300 by 1484 (Austin 2007, 76). Changes in ownership, absentee lords and the long wardship of a juvenile heir

would all have precluded innovation in breeding the desmesne livestock and encouraged maintenance of the *status quo ante*.

ii. The Breeding Season

Some hints with regard to seasonality of breeding are present in the literature. The vaccary cows were sent away to the summer pastures for up to six months. One historical example from Wales gives August to February as the months for the bulls to run free (Sheringham 1982, 702). This implies that the bulls remained on the lowland hendre and that the cows returned from the mountain hafod for these months. This would result in calving from May to November, irrespective of when the cows first returned to oestrus on the hafod.

The later medieval and post-medieval records for shielings in the North Pennines contain no references to the bull accompanying the cows, in contrast to the stallions and tups who appear regularly in the manorial court paines (Winchester 2000 and pers. comm.). There were therefore several months over spring and summer when the cows were not running with a bull. In this situation, the modern cow in heat will be mounted by other cows. This is not normal behaviour in wild ungulates and is considered to be an artefact of husbandry in domestic cattle (Hall 1989, 223). Whether this behaviour arose as an inadvertent response to segregation of cows from the bull or was a trait actively selected for, to allow human manipulation of breeding, is unclear. Such behaviour is still actively promulgated in modern commercial dairy herds, to monitor oestrus activity and the timing of AI. This behaviour was certainly observed in vaccary cows, being depicted in the mural known as "Die Augsburger Monatsbilder", in Augsburg, Germany, dating to the 1520's and showing the seasonal attributes for each month. The detail of the vaccary cows for the month of April clearly shows one cow mounting another, Plate 4: 2. The systems of summer grazing in upland regions therefore applied different selection pressures with regard to seasonal breeding, compared to lowland steadings with the bull available all year. Obviously such behavioural traits are invisible in the skeleton but in cattle reiving societies, with continual acquisition and loss of cows, heat detection by cows mounting each other could be seen as a useful attribute for sorting cows into management groups.

iii. Everybody's Daughter

"Nobody's son on everybody's daughter" was the derogatory phrase used by the 18th century improvers to indicate the breeding of livestock prior to the concept of pedigree recording. In fact, the previous discussions in Chapters 2 and 3 have shown that there was rigorous selection with regard to which cattle should be reared for breeding. Such selection criteria were the result of many centuries of empirical observation and functioned at the broad population, as opposed to individual herd, level, comparable to wild animals. Rather than the modern concept of actively selecting *for* a trait, traditional husbandry generally selected *against* traits, though with some exceptions, principally friendliness. This was selection by culling out rather than by breeding in. In societies where cattle reiving was an integral and honourable aspect of society, there could be no improvement by selective breeding, only by culling.

The zooarchaeologist also needs to think differently from 18th -21st century farmers and commentators and to understand the basis behind the superstitions, as a means of passing empirical knowledge down through the generations without being lost or forgotten. "Everybody's daughter" had in fact survived rigorous selection in being raised in the first instance. Her mother was proven, having already produced at least one calf and had been chosen either "for breed" or for her heifer calf to be reared on the pail. She, herself, was not born in the spring, at the peak of milk production and forage supply, and had survived her first winter, possibly with minimal shelter or supplementary feed. She fulfilled the later criterion of "survival of the fittest" and was "fit for purpose". That purpose may not be equivalent to those required of more recent cows, and may have included such attributes as the, currently outmoded, ability to be driven hard over rough going if taken as prey; longevity; friendliness or docility at milking; calorific return and milk quality from minimal forage input.

It was axiomatic in the later 18th century that "Everybody's Daughter" needed to be "improved" and "improvement" remains an attribute for which zooarchaeological evidence is sought, though this quest for "improvement" rather tends to ignore the concept of cattle as capital assets. One would expect to enhance the return on a capital investment but this may be achieved by expanding the asset base, by breeding more cattle, rather than selective breeding for whatever trait may be deemed an improvement, in zooarchaeological terms normally considered to be either an increase in size or a change in skeletal proportions. As noted above, if milch cows

were owned by landlords and leased out seasonally in vaccaries to dairy workers, there would be no incentive to change breeding policy if the financial return on this system was deemed satisfactory to the accountants. There would be no reason to increase milk yield if there was no corresponding increase in demand for dairy products. A small output of high value product may be more profitable than a large output of low value product. An increase in output could be achieved by increasing the number of vaccaries rather than the yield per cow. If cows were seen as wealth on the hoof, then in the aftermath of human and livestock population crashes, such as those seen in the 14th century, it would be possible to argue that larger numbers of low-yielding and/or smaller cows would be a more desirable capital base. The discussion of the Barnard Castle vaccaries, above, demonstrates that the zooarchaeologist needs to consider whether the logistics of possible "improvement" would have been feasible for a specific site and assemblage before making speculative suggestions. As Cobbett's recommendation above demonstrates, the householder with only a cottage, or croft and toft, would also have provided a continuing demand for productive small cows and hence a brake on the dissemination of larger cattle.

Improvement in the sense of recorded pedigree breeding requires individual identification of the animals, by name or number or a combination of both. Names may be bestowed on cow families, such as Grinstead Trixie 8th in Plate 4: 1, a system still followed by many pedigree cattle breeders. It is generally assumed that large herds, having a broader genetic base to work with, will have more potential for "improvement" than small herds, or the archetypal poor widow with a single cow. However, small-scale cow-keepers would acquire personal knowledge of individual cattle in a way that is not possible with a large herd, particularly medieval vaccary herds where cows were both leased out and received in as rental payments. Many single cows kept to about 20 years old, having produced upwards of eleven calves and lactations, could in theory contribute as much founder effect to the local cattle stock as a manorial herd, probably replacing vaccary cows after fewer lactations. The small-scale cow keeper could not afford to have an unproductive cow, whereas a large herd run by managers or leased would lack the personal incentive to select for individual productivity. The naming and close personal relationship with the single cow may have contributed as much to productivity as breeding. This is another instance where empirical observation has been proven, naming cows and giving attention to

individuals has the beneficial side effect of a quantifiable increase in milk production (Douglas & Rowlison 2009).

Fussell (1966, 10-32) summarises the historical development of dairy cattle from 1500-1900 and concludes that the Tudor farmer's animals would appear to modern eyes as dwarf bags of bones, misshapen through ill-feeding and casual breeding and ridden with disease. A similar attitude to traditional dairy stock was apparent in late 20th century India, described by George (1985, 276-7) as a fundamental assumption that existing systems of milk production and marketing were backward and deficient and therefore should be replaced. George refutes this supposition, making the point that "backward" holds only in the sense that the native dairy industry has a tradition and continuity of many centuries behind it and the constraints within which it has to function have an equally long history. Within these constraints skilled breeder castes continue to produce excellent indigenous draught, milch and dual purpose stock with milk quality (author's note: **not** quantity) being superior to exotic imported breeds.

In defence of the Tudor farmer, it is salutary to consider the current apogee of the dairy cow: the Holstein-Friesian. Rather than a dwarf, even top show cattle are merely a giant bag of bones. To counteract this, when mating inferior cows to a beef breed, the Belgian Blue is a preferred sire. This breed has extreme double muscling on the hindquarters resulting in difficult births (dystocia), requiring assistance frequently to the extent of a caesarian section. The double muscling means the animals are incapable of walking with the gait of normal cattle and the bulls have lowered libido. It is not disputed that a variety of diseases are endemic within modern dairy herds, with the most prevalent being IBR, BVD and leptospirosis (Farmers Weekly 10/11/2006, 41). Also widespread are Johne's Disease and tuberculosis. BSE was particularly a disease of Holstein-Friesian dairy cows, fed large quantities of concentrate feed to sustain production. Damaging the productivity of these Holstein-Friesian cows is the high incidence within herds of subclinical mastitis and lameness, discussed in more detail below, associated with cows standing in slurry on concrete surfaces. The modern Holstein-Friesian is a victim of Boulding's Utterly Dismal Theorem (Glantz 1976, 20). The Tudor farmer could therefore justifiably be equally scathing of modern bags of bones, animals grossly misshapen through deliberate breeding policies and endemic diseases largely unheard of before the late 20th century, caused by husbandry practices alien to the 16th century.

The implementation of Operation Flood to "improve" milk production in modern India has spawned a wealth of dispassionate literature analysing the pros and, predominantly, cons of the received wisdom of such improvement in the face of international financial interests and indigenous government corruption (Alvares 1985; Doornbos *et al* 1990; George 1985). The impetus to livestock improvement in late 20th century India mirrors that of late 18th century Britain: demand from comparatively well-off urban consumers. The knock-on effects are also comparable: rapidly increasing poverty of the most vulnerable members of rural society with the loss of common grazing, loss of local milk and milk by-products, loss of arable land to grow fodder crops and breakdown of customary village support networks. Further, the traditional roles of women in dairy work are removed by men, who benefit both in terms of nutrition and cash income at the expense of women (Doornbos *et al* 1990, 179). Although the concept of Operation Flood was lauded as improving the lot of the rural poor, the practical result has been to depress their situation further.

"Improvement" in the quantity of milk yield has been at the expense of milk quality and nutritional value. Industrialised urban demand for liquid milk has led to the loss of traditional breeds producing small quantities of high quality milk suitable for cheesemaking. The inputs required to produce the increased volume of milk far outweigh the value of the extra milk in terms of calorific return. The product is bland and homogenised and the environmental and social costs far outweigh the benefit. A similar result was produced by unscrupulous dairymen, who merely watered their milk to increase the volume. "White water" is a term used by Holstein-Friesian breeders to describe their own product.

In the mid 20th century Smith and Wilcox (1951, 140-143) gave an honest appraisal of the result of 150 years of pedigree breeding for improvement of milk yield and the use of such pedigree bulls to grade up commercial cows. For every "improved" milking heifer sold with great publicity there was equally one poor yielding heifer, sold on quietly. While it was acknowledged that such heifers should not be allowed to enter the breeding pool if the general standard was to be "improved", in practice to make a living the cash return from selling on the sub-standard heifers was essential. Equally the finest milker of the time was a non-pedigree cow of unknown ancestry, either the same or a similar animal is shown in Plate 4: 3. The prediction that the creation of a standard cow of predictable yield was beyond the capacity of individual herds but required resources on a national scale

came true in the later 20th century with the adoption of AI, bought from international firms with the resources to progeny test the bulls' daughters for milk yields before releasing semen for sale. This has not been an unmixed blessing with the inadvertent global spread of undesirable recessive characters, see CVM in Chapters 2 and 3.

iv. Artistic Representations

Amoroso and Jewell (1963, 126-137) discussed the physiology of milk let down and illustrated this with ethnographic data and a selection of depictions from ancient Egypt to medieval Europe showing either the presence of the calf or a range of subterfuges to stimulate the cow to let down milk. The caption to Plate XIV that "it would appear as though it was an article of faith with these ancient peoples that a cow would not give her milk without the presence of her calf" appears to be generally unquestioned in the zooarchaeological literature. However, as noted in Chapter 3, such images all depict young calves that might fall into the window of overlap when milk was drawn but the calf was also allowed to suckle. An example is the red heifer in Plate 3: 1, who is restrained by a neck tie and has her calf present. The dairymaid is milking one-handed and holding onto the pail suggesting, from personal experience, that the heifer is still being trained to milk. Such a scenario would not present a problem on the home steading but would be rather more cumbersome on the upland summer pastures. Photographic evidence from the early (Hartley and Ingilby 1981, Plate 96) and mid 20th century, Plate 4: 3, shows that these recent cows stood unrestrained in the open field to be milked. The milkers are exploiting another aspect of cow behaviour associated with milk let down, that of "standing" for the calf to suckle. The example of Tiggywinkle and Gundrada showed that this too can become rapidly conditioned behaviour in the overlap period of milking and suckling. The advocates of the belief that the calf was necessary for milk let down rarely consider the variety of images from the 15th century onwards, showing unrestrained cows standing to be milked without the calf present. Examples include a 15th century wall painting for the month of June, from Trento in Italy, showing what appears to be an upland vaccary, with a range of temporary structures. In the scene are seven cows, one milkmaid milking an unrestrained cow, one milkmaid churning butter and a further two engaged in cheese-making. Calves and bull are conspicuous by their absence (Pérez-Higuera 1998, 179 & 193). The context of such art is discussed by Pérez-Higuera (1998, 176), who notes the introduction of dairying scenes in the 15th

century and associates this with the change from calendars of seasonal activities as public art in religious buildings to depictions in Books of Hours and missals, commissioned and owned by the wealthy for household use. The spring time scenes of cattle milking and dairy production in such works may therefore reflect seasonal activity generating income for landholders who could afford such books. Further examples include a Flemish illustration of what appears to be a hill side vaccary with four cows, one being milked unrestrained, but only one calf (Hartley 1969, 72). Plate 4: 4 is an early 16th century French image of an unrestrained cow without calf being milked on the steading. Such milking scenes, taken in conjunction with the evidence for calf slaughter discussed in chapter 3, suggest that the concept of a vaccary or dairy cow amenable to being milked in the absence of the calf, and without restraint, had emerged by the 15th century.

These illustrations may also be used to elucidate what was meant by "the cow with the crumpled horn". This animal survives in the children's story of the House that Jack Built, dating from the late 17th century (Green 1899, 89-99). However, the distinguishing feature of the crumpled horn is of some antiquity in denoting a dairy cow, being listed by Markham (Best 1986, 166) as a desirable attribute. This is an example where a criterion for selection in the past no longer appears logical to modern breeders, though the association of horn shape with dairy productivity was current in the Ayrshire breed into the first half of the 20th century, for example being depicted on the dust jacket of The Dairy Farmer's Encyclopedia (Morley 1950) as the epitome of the then ideal dairy cow. The late and post-medieval artists would be using commonly understood motifs, so a dairy cow should be instantly recognisable to the viewer as having the desirable "crumpled horn". In this context, a crumpled horn would appear to have been the upright, lyre-shaped horn type which is still associated with geographically diverse traditional dairy breeds, for example the Norwegian Vestlandsk Fjordfe, Italian Cinisara and Irish Kerry, Plates 4: 5a-b/c. The phrase "a crumpled horn" retains the now obsolete meaning of curved, also seen in the historical musical instrument the crumhorn, meaning a curved horn, popular between the 14th and 17th centuries, a timescale overlapping the illustrations under discussion. Subsequently, a crumpled horn came to mean one horn up and one horn down, as used in Highland cattle (Grant 1995, 151). This is an example of a mistery of husbandry becoming a mystery with the passage of time. Horn core shape is an

attribute that is not normally considered in conjunction with gracile build as potential zooarchaeological evidence for dairy conformation in cattle bones.

An example in the round of a cow with dairy conformation is the sculpture group on the west corner tower of the east transept of Durham cathedral, popularly referred to as the Dun Cow from the legend of the founding of the cathedral. The present sculpture dates to the last quarter of the 18th century and replaced the previous, heavily weathered, statue group (Hutchinson 1787, 226). The original medieval composition of the group appears to have been retained and the size of the niche constrains the size of the figures, which are smaller than life size, Plate 4: 6a.

The sculpture of the cow exhibits typical dairy conformation. From ground level, the udder of the cow is prominent with a large milk vein clearly depicted. The outline of the body shows the typical dairy wedge or triangle and she is not a beefy animal, both the ribs and spine of the scapula are clearly depicted. The cow has rather more stocky, or robust, legs than might be expected from the rest of her build but this may be a purely practical consideration, dictated by the necessity to support the sculpture.

A later 19th century American commentary on the same sculpture is of interest, particularly the assertion that living models were used, and continues: "The cow is an unmistakable Short-horn all over, the legs excepted, which the learned librarian of the Cathedral informed me were chiselled *unnaturally coarse*, by fault alone of the sculptor; otherwise it is a tolerable representation of a good animal. The style of the cow is that of long-gone years, when the Short-horns were less refined than now. She is represented in moderate condition, with full udder and large milk veins, just as one would appear when yielding a full flow of milk. The figures, it will be observed, are altogether disproportioned, the maids being too high and the cow too low in stature" (Allen 1872, 20-21). Not only was the American commentator seemingly unaware of the existence of Dexter-sized cattle, see Dedication for comparison of human and cow height, the accompanying sketch, Plate 4: 6b, shows that the cow acquired a layer of beef that is not present on the original in Plate 4: 6a. The predilection for enhancing the beefiness of Shorthorns in pictures, see Chapter 6, appears to have extended to the Dun Cow, whose lean appearance is comparable with the 15th- 16th century images discussed above. The portrayal of the Dun Cow as a small, classic dairy type is of interest given the date of the sculpture, which coincides with the widespread enthusiasm for the creation of massive beef type animals by

wealthy and literate gentleman farmers. The cow is probably representative of the small, local cattle, the type of animal approved by Cobbett but dismissed by Bewick (1807 facs.) as "our horned cattle are universally allowed to be the finest in Europe; although such as are purely British are inferior in size". Minton (2002, 201) points out the element of risk attached to innovation and that this would be unacceptable to the average farmer, who would wait until such ideas were proven financially, leading to slow adoption of experimental methods. This may be part of the explanation for the co-existence of the small, old-fashioned dairy cattle with the new, large, improved beef beasts seen in the archaeological record (Gidney 2009).

4.2 Data from Modern Herds

i. Milk Records and Milk Quality

Milk records are integral to dairy cattle, whether to monitor production or, as suggested by Walter of Henley's ideal figures for accountants, to discourage dairy staff from creaming off the profit. Thompson (2005) has provided a very useful synthesis of the disparate information available for medieval and post-medieval lactation yields. Some of the medieval yields appear pitifully small until, as Thompson points out, it is understood that this is milk in excess of that needed for calf rearing. Chapter 3 demonstrated that calves ceased to suckle by 8 weeks old. While not explicit, pail feeding of whole, watered or skim milk is probable thereafter. Cows were generally milked only during the 24 weeks when the weather was sufficiently clement for cheesemaking, again a factor indicating that the historical records are of partial lactations only. Milk yield would also be affected by the stage of the lactation curve (Board on Agriculture 2000, 44) that fell within the window of the cheesemaking season but after the calf was removed from suckling. It can be seen from Figure 4: 1, comparing the yields of low to high yielding cows over 30 weeks of lactation, that maximum production falls between the 5th and 15th weeks and declines sharply thereafter. By the 30th week, the yields of both high and low yielding cows even out. If the milking strategy were to allow the calf to suckle for 6 months and milk the cow thereafter, there would be little apparent incentive to select for milk yield. Taking milk only at the end of the lactation could easily explain some of the apparently poor historically recorded milk yields. Conversely, killing the calf at about 8 weeks old would liberate the peak of the dam's milk supply for the milker and the

difference between high and low yielding cows would be apparent. Volume of milk is not necessarily desirable in the absence of quality in terms of butterfat and solids not fat and a predictable flat lactation yield can be preferred for cheesemaking over a peak and fall-off lactation.

The Vycanny herd of Dexters was hand milked during the 1950's but unfortunately milk records were not routinely published in the DCS herd books and, on enquiry, it transpired that Miss Roberts had not kept the original record sheets. Further enquiry of National Milk Records also failed to locate this information. The surviving milk records for 88 lactations from the period 1952-1972 have been examined, as this was a period when the Vycanny herd was managed on very traditional lines and before Jersey cross breeds were retained in the herd. Average yield was 428 gallons (1943 litres) with a range of 150-718 gallons (681-2818 litres) and a standard deviation of 139.6 gallons (633 litres). Average butterfat was 4.05% with a range of 3.04%-5.56% and a standard deviation of 0.5%. Just over half of the lactations in this sample reached the target recording period of 305 days. Figure 4: 2 shows the distribution of days in milk, omitting the extreme examples of 160 and 357 days respectively.

By way of comparison, Fussell (1966, 222) gives an example of average milk yield in 1891, when the Shorthorn was pre-eminent, being of the order of 570 gallons (2587 litres). For the size of the animal, it can therefore be seen that the mid-20th century Dexter under traditional management was an effective milk producer. Thompson's (2005, 139) lactage estimates of 47-125 gallons from manorial accounts of dairy production could be interpreted as a third, or less, of the total lactation being taken for dairy production. Teichert's (1993, 236) contention that Roman to Medieval cows of 0.95-1m withers height would not have exceeded annual milk production of 500kg (1100lbs or 110 gallons) can be seen to be potentially spurious when compared to the recorded output of the Vycanny Dexters of this size range.

Although Thompson (2005) was studying manorial accounts, it is not wholly clear whether these accounts relate to the specialist vaccaries or the general purpose desmesne herd. The latter may be suggested by Thompson's (2005, 135) emphasis on the production of bull calves, and the leasing out of vaccary cows (Thompson 2005, 138). As noted for Barnard Castle (Austin 2007) many of the cows in the desmesne herd that were milked may have been kept primarily for breeding draught oxen. This

strategy of taking cow's milk as a by-product of producing draught-bullocks is still extant in India (Doornbos *et al* 1990, 181) and will be discussed further in Chapter 5.

The Vycanny herd gives an indication of what the medieval vaccary cows, of comparable stature, grazing similar pastures in the uplands of Teesdale, might have been capable of producing in 3-6 months. In contrast, Thompson (2005, 140) suggests that the expected dairy returns in the treatises of Walter of Henley and the Husbandry were rarely achievable in real life. Since the Dexter breed is of Irish origin, the Vycanny cows also suggest why the Irish creaghts were such an important resource.

The other method of sharing the milk yield between the calf and the milker is described by Grant (1995, 214) for a late 18th century farm in Wester Ross. The cows and calves were kept separate. At milking time the cows were tied up and the calves released one by one. The dairymaid and the calf then engaged in a race to strip out the cow. This method is implicit in the descriptions of the mobile Irish creaghts (Lucas 1989).

Milk yield is an attribute that has been selected for modern "improvement". Fussell's (1966) view of historic dairy cows appears to have been coloured by the official stance of his employers at the Ministry of Agriculture. Smith and Wilcox (1951, 84-5) present the other side of the coin, with the viewpoint of the family farmer. Having tried the advice of the Dairy Inspector to feed high performance cows to yield and milk three times a day, Smith and Wilcox elected to run a system based on lower feed inputs and lower milk outputs because they preferred their cows "to last and live to a ripe age". The recorded milk yields discussed by Thompson (2005) suggest that the medieval cow keeper sided with Smith and Wilcox.

A point that is rarely considered by traditional commentators on the milk yield of medieval cows is what the nutritional value of the milk might have been. Dahl and Hjort's (1976, 153-6) study of modern nomadic cattle shows that while the yield is low, the quality of the milk is high in terms of butterfat and nutritional value, estimated at about 830 kcal/litre compared to 660 kcal/litre for European milk. A much smaller volume of such milk is therefore needed for the same nutritional return. Such high quality milk is a better product from which to make cheese and butter, compared to the contemporary Western demand for retail liquid milk. George (1985, 86) makes the point that high butter fat is an important consideration in societies without the benefit of refrigeration, where milk must be processed since it cannot be kept long or transported in fluid form. Attempts to introduce the Jersey, the Western

breed with the highest butterfat %, to "improve" the productivity of indigenous cows in India have met with failure as "the heifers of Jersey cows are of no use" and "ghee cannot be extracted from the thin milk of Jersey cows" (Alvares 1985, 127). This demonstrates that one culture's definition of rich milk is another's definition of thin milk and that quality, rather than quantity, is the desideratum of the traditional cow-keeper.

This has interesting implications for the ongoing debate about the intensity of milk production in Neolithic societies. An apparently small amount of product may have yielded a high calorific return. A lack of understanding of dairy utensils is demonstrated by Greenfield (2010, 44) who suggests that since only 25-30% of Neolithic pottery sherds demonstrate evidence of milk lipids, milk may not have been a primary objective of animal exploitation. In fact the majority of dairy utensils were traditionally made of wood and even a post-medieval dairy sported "no finery of china or glass *or even coarse earthenware*", (author's emphasis) (Grant 1995, 213). Vigne and Helmer (2007, 14) present evidence that milk was heated in these Neolithic ceramics but fail to comprehend that warmth at body temperature is necessary for the action of rennet. Neolithic dairies would have to use ceramic vessels for this process in the absence of metal vessels. The argument that fermentation techniques for dairy products were "too sophisticated" (Vigne & Helmer 2007, 12) for Neolithic cow-keepers is facile. Warming milk to blood heat and dunking part of a calf's stomach bag in it to curdle the milk is hardly beyond the imagination of any nursing mother or calf butcher. Treating milk in this way also renders obsolete all the arguments of lactose intolerance in humans precluding the consumption of liquid milk. This is projecting a modern consumption pattern of a modern product into the past, when the milk itself would be of a very different quality with the emphasis probably on a solid rather than a liquid for consumption.

Modern milk records are based on the concept of a 305 day recorded lactation, predicated by an annual calving. However if, for any reason, the cow should not be in calf, there is no necessity to dry off the cow and therefore milking can continue. This strategy was used deliberately by post-medieval urban dairies, with the cows going to the shambles when they eventually dried off (Smith 2000, 325-6). In the 19th century, some herds went to the extreme of spaying the cows once they were in milk, so the oestrus cycle did not disrupt the milking routine (Jennings 1864). At a smallholder level, this approach to domestic milk production still continued in the mid 20th

century, with the example of the elderly spinster purchasing the elderly barren but in milk cow (Smith and Wilcox 1951, 134).

Milk is not a "free" resource as production of milk beyond the immediate needs of the calf requires the cow to be fed for such production, in addition to the ration necessary for body maintenance. The exponential increase in milk production in early lactation frequently has to be met from the cow's own reserves, referred to as "milking off her back". Subsequent nutritional levels therefore have to sustain lactation and the next pregnancy while replenishing body condition. It can be seen that milk output depends on feed input and human decision making on balancing the two. Once this is understood, the recorded milk yields of medieval cows that were so derided by commentators such as Fussell (1966) may actually represent a very efficient use of manorial resources. Rather more dispassionate studies of modern Indian cattle show that, in terms of net annual food calorie balance, the calorific input the cow needs for the calorific output of the milk yield, the indigenous cow fed on agricultural waste and wayside grazing provides the best return (Doornbos *et al* 1990, 182). Even a modest ration of complementary feed, while increasing milk output, decreases the calorific return. The addition of large quantities of green fodder, grown especially for cows, together with complementary feeds, places the dairy cow in competition with the human population for limited resources. The additional milk produced contains far less calorific energy than that obtained by direct human consumption of vegetables and arable crops grown on the same land (Doornbos et al 1990, 182). Discussion of the feed inputs necessary for the recorded milk outputs are singularly lacking in most discussions of historical milk yields. This type of food calorie balance helps to explain the productivity of mobile pastoralists, such as the Irish creaght. The cows grazed as they moved on grass not necessarily belonging to the herders. No human time and energy was taken up in growing and conserving fodder crops. In winter, the cows made do with woodland shelter and grassland that had not been grazed but allowed to die off (Lucas 1989). In 19th century Africa, it was observed that the small native cattle fed quickly compared to the large European breeds. As they ate a grass patch completely, rather than cropping here and there, the small cattle were full sooner, could lie down to cud and rest and so were ready to move on before the larger beasts (Stoppard-Rose 2013, 68). It can be seen that this might have been a useful attribute when the cows were a mobile victualling unit for a war-band, producing daily fresh, high energy, fat-rich milk readily consumed, for

example, as curds and whey. This potential for provisioning conflict is one aspect of the secondary products revolution that is not explicitly discussed by either Vigne and Helmer (2007) or Greenfield (2010), the milch cow as mobile war chest.

ii. Practicalities of Milking

Chapter 3 drew attention to the sources describing the gradual changeover from the calf sucking the dam to the dairymaid taking all the milk. An inadvertent example of how this system may have worked in practice was provided by the illness of the calf Gundrada, described in Chapter 3. Her dam, the first-calved heifer Tiggywinkle, within the two week period of the calf's incapacity rapidly became accustomed to the routine of coming into the barn to the calf and standing while milk was taken for the calf. After the death of the calf, Tiggywinkle endeavoured to continue with this routine and several lactations later still has a spontaneous let-down of milk when newly calved and the author enters her pen. This experience was in stark contrast to the author's attempt to milk Chalena, the foundation female of the Zanfara herd, when newly calved. This was very painful for all concerned and tended to support recent received wisdom (Miss Roberts, pers. comm.) that allowing the calf to suckle and hand milking was not feasible. The medieval method in fact shows a much greater understanding of cattle behaviour. The cow is extremely protective when newly calved but, as observed in Chapter 3, the bond gradually starts to weaken by about 10 days *post partum*. By commencing milking three to four weeks after calving, the initial aggressive response of the dam would have been avoided. The example of Tiggywinkle shows that penning the calf inside a building and bringing the dam to the calf twice daily can rapidly produce a conditioned response in the dam, which continues after the death and removal of the calf and remains an active response at subsequent calvings. Sharing the milk of the early lactation with the calf, particularly a heifer calf for rearing, would have trained it in this management system ready for the time when it calved itself. This method of gradual changeover between suckling and hand milking would also have meant that medieval cows could have been readily exchanged between the specialised vaccary milking herds and the general herd "for breed", rearing calves then milked in late lactation. The cows would have been docile for the pail but would have also retained the ability to mother and rear calves when required.

iii. Lameness in Dairy Cows

In modern British dairy cattle, lameness is a major problem leading to loss of milk production, reduced fertility, increased veterinary overheads and culling of otherwise productive animals. Watson (2007) discusses the principal conditions encountered today. Most of these problems are infrequent in beef suckler herds, and so are unlikely to have affected the animals represented in the archaeological record. Such lameness is directly related to diets based on silage, maize and concentrates, leading to the production of slurry, rather than traditional straw-based farm yard manure (FYM). Another major contribution to lameness in modern dairy cows is the use of concrete surfaces in yards and housing. A further factor predisposing to lameness is unsuitable surfaces on cow track ways leading from grazing to the milking parlour, exacerbated by too rapid a pace using coercion from herdsman and dogs (Watson 2007, 145-7). Given the immense distances travelled not only by droves of beef cattle but also by milking cows in the Irish creaghts (Lucas 1989, 68-124), and the haste with which all cattle were moved by Anglo-Scottish Border Reivers (MacDonald Fraser 1974, 84 & 90), this could well be applicable to conditions seen among archaeological finds. Other pathological conditions, such as dislocated hips and fracture of the tuber coxae (Watson 2007, 112-4), should be visible in the archaeological record, if the pre-disposing management factors were present. The modern veterinary literature is of help in interpreting which conditions would necessitate culling of the animal and which, though appearing dramatic, would not cause the animal a long-term problem, for example cows with "knocked down hip" or fractured ilial crest (Watson 2007, 114). Problems with the pelvis and hip joint in modern cows are associated with extreme dairy conformation, with little muscle mass and no fat covering on the pelvic region, resulting in simple injuries causing serious skeletal damage (Watson 2007, 107). In archaeological terms, one might expect the incidence of such injuries to be seasonal, occurring around February-May when both the Irish (Lucas 1989, 109) and Anglo-Scottish border (MacDonald Fraser 1974, 71) records show that cattle were at their leanest and weakest.

iv. Dwarf Dairy Cows

Chapters 2 and 3 have drawn attention to the chondrodysplasia present in the Dexter breed, expressed as the short-leg heterozygote and bulldog calf. Such dwarfism will now be considered in the context of the milch cow. Even in the 19th

century heyday of the large "improved" breeds, Malden (1894, 531-540) appreciated that such animals were not always suitable for the sparsely pastured mountains, forests and jungles of the British Empire. Malden therefore sought a small hardy hill British breed of cattle to impart "superior points" such as milk production, to Indian hill cattle, but found such breeds were no longer common. Several Dexter crosses were studied with the suggestion that the Zebu-Dexter cross had the potential to greatly increase the value of cattle in India for the British. Fortunately for the cattle of India, this suggestion never appears to have been implemented. Malden emphasises for the Dexters and their crossbreeds both the quantity of milk produced for the size of the cow and feed consumed and the quality of the milk in terms of butter production. Since Malden was advocating first crosses, bulldog calves did not impair the results.

As seen in Chapter 3, dwarfism in 20th century American range cattle was seen as financially detrimental for beef production and great efforts were made to eradicate the carrier animals. However, a contemporary study of Puerto Rican cattle (Arrillaga 1949) suggested that female dwarves of the indigenous *criollo* cattle might be more productive than conventional breeds in the mountainous regions of tropical America. Dwarfism would appear to have been a trait in the cattle introduced to the Americas by the Spanish settlers as a further *criollo* breed, the Florida Cracker, also has a dwarf variant known as the Guinea. Guinea cows were retained because of the high milk yield for body size but if mated to a Guinea bull could produce bulldog calves. Again in the mid 20th century, a Jersey herd in California was studied in 1944 (Mead *et al* 1946) because of the high proportion of dwarf cows in the milking herd, following the use of a dwarf Jersey bull on the herd. Sire on daughter matings produced instances of bulldog calves. The dwarf heifers had been retained and bred back to their sire because all the daughters, both normal and dwarf, of this bull were high milk producers, while most bull calves were killed at birth. It can be seen that there was a striking difference in contemporary attitudes to dwarfism between beef and dairy farmers in mid 20th century America and potentially such a dichotomy between the yoke and the pail may be transposed into the past. It can be seen that dwarfism is not a pecuniary liability in the cow, who milks as well as her normal sister in relation to body size and feed input, ***if*** milk is the prime output of the herd. Figure 4: 3 shows that the heights of the cows in this Jersey herd (Mead *et al* 1946, 186) produce a bimodal distribution, with no overlap between dwarf and normal. This

is salutary for the interpretation of similar graphs from archaeological data, where a standard suggestion would be that the smaller cattle were female and the larger male. The example of the Jersey herd also demonstrates how the Dexter may have arisen as a variant of the Kerry, in the early 19th century, before becoming an established separate breed in the later 19th century. Pringle (1872, 2) indicates that it was then unknown whether the Dexter arose as a cross with the Kerry or selection within the Kerry. The birth and retention of a chondrodysplasia carrier bull calf, subsequently inbred in the eponymous Mr Dexter's Kerry herd, could be sufficient explanation. The example of the Ancon sheep (Gidney 2007a) demonstrates that this principle was known and understood by the time the Dexter was created.

4.4 The Dexter Dairy Cow Reference Skeletons

This project was very fortunate to obtain four cows for skeletons from the Vycanny herd of Dexters. This was a small dairy herd, milking 10-12 cows, at Woodland in Co. Durham at an altitude of about 1000' (c. 300m) comparable to the author's Zanfara suckler herd at Tow Law. The Vycanny and Zanfara holdings were also of similar size, 11-12 acres or 4-5 hectares and both fall in the DEFRA classification of "severely disadvantaged" land. The management systems were quite different. The Vycanny cows were housed from November to May in a traditional byre with hardstanding and neck chains, whereas the Zanfara cows are normally housed from December to April in deep litter straw pens. The Vycanny herd was inaugurated in 1948 and continued to be run according to mid-20th century principles into the 21st century. In the 1950's the herd was hand milked and won several regional awards from the MMB in the 1950's for the quality of the milk in terms of the butterfat content, not the overall yield, for a standard 305 day recorded lactation. All the senior herd sires were awarded RM status on the basis of their daughters' production records. It is significant to note that milk quality was still more valued than total volume produced when the Vycanny herd was established. After the introduction of milk quotas in the 1980's, the cows continued to be milked and production recorded but the milk was bucket fed to commercial calves. The Dexter calves were taken away from their dams as soon as they were born. The cows were not allowed to clean, suckle or bond with their calves. The calves were not fed on their day of birth, contrary to modern thinking that calves should have colostrum

within 4-6 hours of birth. Calves were bucket fed with watered colostrum followed by watered milk. The bull was not allowed to run with the cows. In winter the bull had a separate pen in the byre and in summer was tethered in a separate field and bulling cows taken to him. In her later years, Miss Roberts had a self contained bull pen with service area constructed, to best 1950's specification (Barron 1950, 71). The bull was then housed, isolated from the herd, all year round. Miss Roberts was a vehement adherent of the opinion that the short-legged Dexter was the correct type, so no non-short calves were retained. The Vycanny cows were actively bred to be a "level herd", standing at 36" (91.5cm). The horns were kept on all the Vycanny cattle. All heifers were normally inseminated to another breed, usually a Jersey, for their first calf, since these were not to join the herd.

In winter, the Vycanny cows were fed hay made on the holding, straw and a small supplement at milking time, principally composed of rolled oats. Straw was used as a feedstuff, not for bedding the cows. In summer, the cows strip grazed the fields, controlled by an electric fence. The cows were not turned out until the grass could sustain this method of grazing. The Zanfara cows are fed bought in hay in winter and straw is used for bedding, though the cattle eat the best of it. When housed, the cows are supplemented with dried sugar beet pulp in late pregnancy and early lactation. After turn-out, grazing within fields is not restricted. Hay continues to be fed outside until grass growth is adequate.

The Vycanny herd was a remarkable survival of cattle management practices that were prevalent in the 19th and earlier 20th centuries (Jennings 1864). Since the whole lifestyle of these cattle was quite different from that of the suckler cows to be discussed in Chapter 5, the osteology of these animals will be examined here. Comparisons with the suckler cows will be made in Chapter 5.

In view of the earlier discussion of the vaccary and desmesne herds of Barnard Castle, the Vycanny herd will be used as a proxy for speculation on the vaccary herd. This is particularly apposite as Woodland would have lain within the boundaries of the lordship of Barnard Castle. Conversely, the Zanfara herd, falling within the former lordship of the Bishop of Durham, will be taken as a proxy for the desmesne herd and discussed further in Chapter 5.

The culling policy of the Vycanny herd is reflected in the annual recorded lactations for the period 1952-1972. Figure 4: 4 shows that up to five lactations, there was no culling, the lower records in this group merely indicate years when these data

were not published in the herd books. After five lactations, there appears to have been a gradual cull but some animals were retained for an 11th lactation to be recorded.

For the period 1952-1967, the age at first calving of twelve heifers that entered the milking herd was calculated. Miss Roberts generally, but not always, retained at least one heifer a year as a replacement, hence the low number of examples. Average age at dropping the first calf was 35 months with a range of 27-54 months and SD of 7 months. Omitting the anomalous heifer at 54 months gives a mean age of 33 months, a range of 27-38 months and a SD of 4 months. So, the Vycanny heifers were about three years old at first calving. A cow with 11 recorded lactations would be at least 15 years old, assuming a lifetime of calving at a regular interval. As will be seen below for the reference specimens, the birth of premature bulldog calves regularly interrupted calving patterns in this herd.

The examples of two Dexter cows of advanced age give an indication of the possible lifetime productivity of the matriarchs achieving 11 or more lactations. The first is Vycanny Conqueror's Glenisla, born 28/11/58 and put down in 1980. Glenisla first calved in 1961 and last calved in 1977. The Dexter Herd Books are an incomplete record but the final milk record in Table 4: 1 is of the 15th lactation. It can be seen that Glenisla maintained a regular calving pattern in April throughout her life, though in her later years she failed to produce a regular annual calf and was barren in the last two years of life. Four of the 15 calvings produced heifers that were registered, including the last calf born in 1977. The 11th lactation was Glenisla's most productive in terms of the quantity and quality of milk. The last two recorded lactations show a dramatic drop in the volume of milk produced, although the days in milk and butterfat % are comparable with earlier lactations. Glenisla early established herself as the Vycanny herd leader and retained this rank until the end. It was for this reason that Glenisla was retained when her calving performance and milk yield declined. An old cow who can lead the younger cows and heifers in the routine of collecting for milking can be of inestimable value in the herd. This leadership role of herd matriarchs is also a characteristic of other ungulates, for example red deer (Fraser Darling 1956, 68-76). Glenisla's retention of the rank of herd leader even when barren contrasts with red deer hinds (Fraser Darling 1956, 68-9) and reflects the artificial situation of a milking herd of adult cows without calves and followers at foot.

The oldest Dexter cow currently known to the author was Parndon Green Finch, born 8/3/66 and still alive for her 29th birthday in 1995 (Schofield 1995, 12), Plate 4:7a, though she died in April 1995. Green Finch first calved 5/4/68 and bred regularly for twenty years, with her last calf born in 1988. The Herd Books are a very incomplete record, as Green Finch had two owners in England and at least two owners after she was exported to Germany in 1970. The Taunus herd, who owned Green Finch from 1975-1995, kindly provided details of her calving record. Green Finch usually calved between February and May from 1968-1988 with seven heifer, two bulldog and eight bull calves recorded. The Taunus herd was officially milk recorded but no lactation records were published in the Herd Books and none of the milk records have been retained. Green Finch is another example where a venerable cow was kept for several years after she had ceased to be productive for reasons beyond mere financial return from milk and calves. This would not be possible in a commercial dairy herd, such as a medieval vaccary, nor in times of dearth but does suggest the possibility that some archaeological cattle mandibles with extreme tooth wear derive from animals where there was a bond between owner and beast that transcended mere economics. It should be noted that both these unusually long-lived cows had retained sound udders into old age and both were chondrodysplasia carriers.

Though not as venerable as Glenisla and Green Finch, the Vycanny cows collected include three over 10 years old:

Vycanny Finbar's Glenteitney 25/4/73- 3/1/90
Vycanny Dormouse's Glenfinlet 6/4/79- 23/2/92
Vycanny Dalesman's Kirstie 17/4/79-19/3/95
(Kirstie in Plates 4: 7b-c is a good example of the conformation of these old cows)
Vycanny (Pug's) Keepsake 9/4/91- 10/9/00

The first three cows are of particular interest with regard to their advanced age. Sten (2004, 67) found difficulty in obtaining teeth from cows older than ten years. All four Vycanny cows appeared to be perfectly fit animals. As far as is known, all the first three cows had fully functional udders, though all were dry and empty at slaughter. They were culled to allow heifers to join the milking herd. Glenteitney was taken to the local abattoir. Unfortunately, the instruction to keep the feet was forgotten, so there are no metapodials, phalanges or centroquartals from Glenteitney.

Since it was then still legal to do so, Glenfinlet and Kirstie were slaughtered on farm by the butcher to avoid any further misunderstandings about retaining bones. Keepsake joined the Zanfara herd for 3 years, producing two calves, before being put down at Miss Roberts' insistence. Keepsake certainly had a sound udder, was in good health and could have bred again, though was empty.

The calving and milk records for these four cows as recorded in the DCS Herd Books, are detailed in Appendix 4: 1. A brief summary is given here:

Glenteitney first calved in 1976, aged 40 months, and last calved in 1989. She produced ten recorded calves, of which two were bulldogs.

Glenfinlet first calved in 1982, aged 37 months, and last calved in 1990. She produced eight recorded calves, of which one was a bulldog.

Kirstie first calved in 1982, aged 37 months, and supposedly last calved in 1995. She produced twelve recorded calves but there is a serious discrepancy with the last calf recorded for 1995 being born a month after she was put down on the Zanfara holding as an empty cow! One calf was described as deformed but none as bulldog. Kirstie was the dam of both Vycanny Keepsake and the steer Carrot, also in this reference collection.

It can be seen that of the 16 year old cows, Glenteitney and Kirstie, only the latter may have achieved the 11 lactations recorded for earlier herd mates. Also, that Miss Roberts appears to have given the old cows time to conceive but the failure to breed was a contributory cause for culling.

Keepsake first calved in 1994, aged 35 months, and last calved in 2000. She produced five recorded calves, though it is possible that the 1995 calf recorded for Kirstie was in fact Keepsake's, who otherwise would appear not to have bred that year. Keepsake was the dam of one of the still-born bull calves in the reference collection. It was not intended to breed from Keepsake while she was in the Zanfara herd, nor was it intended to keep her alive so long. The two calves she produced were unplanned but unavoidable, as the Zanfara bulls run with the herd. The sale of the meat from the cull cows was necessary to fund their purchase but new legislation post 1996, in the wake of the BSE crisis, precluded this option. Keepsake was finally put down on farm while it was still legal to do so and retain the bones. Due to the dairy-focussed management of the Vycanny herd, breeding stock could find some difficulty in adjusting to a suckler herd system. The comparison between Keepsake and the Zanfara cows was very instructive as an indication of how much calf care is learned

behaviour, rather than instinctive. Keepsake's bull calf died, although born in June, because it was dropped in a wet muddy area and no attempt was made to clean the calf. The heifer calf survived because it was born in the barn. The calf's instinct to suckle was strong and Keepsake tolerated it while indoors. When outdoors, she displayed no interest in the calf and had to be brought inside to allow the calf to suckle. The routine of coming into a building to be milked, learned while in the Vycanny herd, appeared to stimulate milk let down rather than the calf bunting the udder.

It is highly unlikely that the specialised system of keeping dairy cows without interaction with their infant offspring, as seen in the Vycanny herd, would have been a viable option in antiquity. Such a system would remove the option of transferring cows between the milking and suckling sections of the herd and, as the example of Keepsake shows, obtaining a cow used to such a system without being aware of the fact could lead to loss of the calf.

i.Skeletal Ageing

All the epiphyses of all four cows are fused and the permanent dentition is present and in full attrition. It can be seen from Table 4: 2 that Glenteitney, Glenfinlet and Kirstie are at practically identical wear stages, MWS 46/47. In fact, were these mandibles not labelled, it would not be possible to readily distinguish the tooth rows from each individual cow, so close are the patterns of wear. This is an interesting indication of tooth wear representing both close relationship between animals and identical feeding and management. This wear stage, MWS 46/47, would appear to represent the Vycanny cull cow cohort, irrespective of actual calendar age: Glenfinlet was some three years younger than Glenteitney and Kirstie. Keepsake was considerably younger but Molar 2 is at the same wear stage as the older cows and Molar 3 at a comparable wear stage. Only Molar 1 shows less advanced wear. Comparison with the bulls is interesting. Cyclone and Keepsake, at eight and nine years old, have almost identical MWS totals, 44/44 and 44/43 respectively. Molar 2 is at the same stage for both animals but Cyclone has more advanced wear on Molar 1 and less advanced wear on Molar 3 than Keepsake. Juglans Nigra was a similar age to Glenfinlet and younger than both Glenteitney and Kirstie but has far more advanced tooth wear than any of these cows. Comparison with the bulls in the Halle collection, Table 2:3, shows that H820, a 6 year old Shorthorn, is also at MWS 46. These data

are a tantalising hint that breeding males may incur faster wear on teeth, with a concomitant reduction in longevity.

Both Glenteitney and Keepsake exhibit congenital absence of mandibular Premolar 2. This tooth is present in Glenfinlet and Kirstie, the dam of Keepsake. O'Connor (2000, 119-121) notes that absence of LPM2 has been recorded in 6-8% of mandibles from excavations in York, which is considerably higher than published occurrences for modern cattle. These examples in the Vycanny cows may support O'Connor's suggestion that this trait may indicate small, or isolated, breeding groups. The counter argument would be that the cows were all sired by different bulls and that Keepsake presumably did not inherit the trait from her dam, unless it is a recessive character which her sire also carried. Ohtaishi (1972) noted the absence of the lower second premolars in a Holstein cow but found that two of her daughters and one granddaughter, by different sires, had the tooth present. This trait is accepted as congenital but little else appears to be known.

ii. Osteology, Pathology and the Dairy Cow

The four Vycanny cows were all chondrodysplasia carriers and show the rugosity and ossification of soft tissue attachments, asymmetrical vertebral articulations, nodules on the caudal margins of ribs and so on described in detail for the bulls in Chapter 2. Since these anomalies are more pronounced on the older cows, they would appear to reflect the age of the cattle and will not be described in equal depth here, being treated as unremarkable for this breed and age range. What will be discussed are anomalies that could appear, or are observed, in the archaeological record. Abbreviations follow those defined in Chapter 3.

iii. Skull and Mandibles

Kirstie's skull has the age-related roughness on the frontal bones developing at the base of the horn cores and along the lateral border. There is also a depression on the caudal proximal aspect of the left horn core, visible in Plate 4: 8, which is mirrored by a depression in the horn sheath. This does not penetrate the sheath but has created an internal ridge matching the depression. An archaeological example is illustrated from Roman Namur and interpreted as "probably resulting from the pressure exerted by the rope that had to keep the yoke in place (Bartosiewicz *et al* 1997, 72-3). Longitudinal grooves in the surfaces of the horn cores are present in all

four specimens. Sykes and Symmons (2007, 519) observe that the incidence and intensity of such grooving appears to increase with age. An earlier assumption of a correlation between such grooving and castration was demonstrated to be false by the occurrence on recent reference specimens of known cow and bull skulls. The horns of Kirstie and her daughter Keepsake fit Pringle's (1872, 2) description of Dexter cows' horns as inclined to be long and straight. Glenteitney and Glenfinlet demonstrate rather more "crumple" but not the "fine cocked horn" of the ancestral Kerry (Pringle 1872, 1).

Glenteitney's skull exhibits resorption with pitting along the maxillary gum lines, indicative of gum inflammation. Kirstie and Keepsake have small OC lesions in the joint surface of the mandibular hinge, with medial osteophytes.

iv. Ribs and Vertebrae

The cervical vertebrae of Kirstie and Glenteitney exhibit lipping of the articular facets on the neural arches with some pitting on the surfaces of the centra, extending to eburnation on Glenteitney's VC5. Keepsake's thoracic vertebrae show slight thickening round the rib facets, suggestive of incipient osteophyte development. Such osteophytes are prevalent in the other three cows, together with osteophytes round the articular facets on the neural arches. Glenfinlet has a few examples of osteophytes lipping and beaking round the centra but well developed examples are present throughout Glenteitney's thoracics. The capitula of the ribs show osteophytes mirroring those present on the thoracic centra. In addition, ribs with mid shaft anomalies suggestive of long-healed fractures are present for Kirstie and Glenteitney. Given the age of these cows, the hierarchical combats to establish a new herd leader after the loss of Glenisla are a possible scenario. All four cows show bilateral occurrence of the blood vessel foramina in the caudal border discussed by Holmes (1981), further indicating that this appears to be a normal trait in this breed. The lumbar vertebrae of Kirstie and Glenteitney show osteophytes round the neural arch articular facets and "beaking" osteophytes on the ventral mid-line of the centra. Glenfinlet has osteophytes ankylosing VL 4-6 at the neural arches, though the centra remain separate. All four cows exhibit anomalies in the articulation of VL 6 with the sacrum. In Keepsake, this is merely expansion of the neural arch facets. In the older cows there is massive expansion and remodelling of the neural arch facets, with eburnation and pitting, extending in Glenteitney to resorption of the right hand side of

the centrum to accommodate the expanded joint, Plate 4: 9-10. The angle of articulation of the sacra with the VL 6 in all four cases implies a raised tail head Plates 4: 11-14. This was a feature apparent in the live herd, Plate 4: 15. A raised tail head is no longer considered a desirable trait, *contra* Markham for example. The pathological changes on these vertebrae indicate one possible reason for this change in opinion.

v. Forelimb

The cartilage on the proximal border of the scapula has ossified on to the bone in the three older cows but not Keepsake. Glenteitney and Glenfinlet exhibit OC lesions on the distal lateral glenoid fossa. The angle of the distal fossa of the humerus has rendered rearticulation of this joint with the radius and ulna impossible in Glenfinlet and the left side of Keepsake, and caused expansion of the articular facet of the semilunaris in the opposing ulna. While this might be considered a manifestation of chondrodysplasia, it was also observed in Chapter 2 for the non-short bull Juglans Nigra and might therefore be a breed characteristic. OC lesions are apparent on the distal radius and carpals of Kirstie and carpals of Keepsake, together with the proximal metacarpals of Glenfinlet, Kirstie and Keepsake. The metacarpals of Kirstie also exhibit proximal and distal anterior "stage 3" exostoses (after Bartosiewicz *et al* 1997), together with expansion of the right medial condyle.

vi. Hindlimb

All four cows exhibit age-related thickening of the ilial-pubic border, described for male cattle in Chapter 2. However, *contra* O'Connor (2008, 173), the female characteristics of the acetabulum and pubis are still readily apparent. Kirstie has eburnation on the right pubic facet of the acetabulum and corresponding eburnation on the right femoral head. Glenfinlet shows eburnation and pitting on the left and right ilial facets of the acetabula with eburnation and pitting on the articulating femoral heads. Glenteitney has eburnation on the distal lateral condyle of both left and right femora, with corresponding eburnation on the proximal lateral facets of the tibiae. Kirstie also has eburnation on the left distal lateral femoral condyle. Glenteitney has visibly more rugose bones throughout the right hind limb, suggesting the extreme pathology described for the right hand VL 6-sacral joint had had a long term impact on the whole hind leg, though without affecting the hip joint.

All four cows show malformation of the distal articular surface of the astragalus, possibly a further manifestation of OC, with corresponding changes to the calcaneum present only in Kirstie. The metatarsals of Kirstie, Glenfinlet and Keepsake all exhibit spavin, that is expansion of the proximal end with exostoses and ankylosis with the centroquartal and tarsal 2+3. The right tarsals of Keepsake have not yet ankylosed to the proximal metatarsal, though the process is complete on the left elements. Glenteitney almost certainly had this condition too, the abattoir had to hack through this joint to remove the hind feet and chopped fragments of the centroquartals were left attached to the astragali. Bartosiewicz *et al* (1997, 70-72) discuss the aetiology of spavin, particularly with regard to draught cattle. Holmberg & Reiland (1984) found the condition prevalent in Swedish dairy cattle, which spent the long winter months tied up in byres, and a heredity predisposition for the development of spavin. Both these factors are relevant to the Vycanny examples.

vii. Phalanges

OC depressions in the joint surfaces of the phalanges are infrequent and minor in the three examples present in both Glenfinlet and Keepsake and one example in Kirstie. In contrast, exostosis development is underway on Keepsake's phalanges 1 and 2 and well developed on Kirstie's. Both Keepsake and Kirstie exhibit pronounced proximal exostoses on all the third phalanges, of the type described by Johannsen (2005, 40-41) as diagnostic of draught cattle.

viii. Measurements

The measurements of the distal trochlea of the humerus are presented in Figure 4: 5a for the four Vycanny cows and in Figure 4: 5b in comparison with the two bulls. It can be seen that the Vycanny cows fall within a very restricted size range and there is clear dimorphism between the two bulls and the four cows. The distal tibiae in Figures 4: 5c-d show a broader size distribution between the four cows but still clear dimorphism between the cows and bulls.

As previously noted, the Vycanny herd bred for cows standing at 91.5cm. Tables 4: 3a-d show the withers heights estimated from five major limb bones, with the exception of Glenteitney, whose metapodials are not extant. While Matolcsi's factor for the humerus (Driesch & Boessneck 1974, 336) does produce height estimates that are in excess of those derived from the metacarpals, the discrepancy is

not as dramatic as that previously described for the bulls. This suggests that the size of the humerus reflects sexual dimorphism, with the bulls having massively built forequarters but not necessarily equally enhanced withers height. The average of Zalkin's and Fock's factors for estimating the heights of cows and steers gives a more accurate indication of the known height range of the Vycanny cows than the equivalent factors solely for cows.

The metrical data from the Vycanny cows will be compared with those from the suckler cows in Chapter 5.

ix. Discussion

Although this is a very small sample of four adult cows from one herd, the data have interesting implications for interpretations of archaeological remains. The potential productivity of such small cows in terms of milk quality rather than quantity opens up another dimension for discussions of chronological changes in cattle size relative to political instability, beyond simple "improved" and "retrograde" stereotypes.

The tooth wear suggests that the cull cow cohort may be selected for factors other than mere age/tooth wear impacting on body condition and performance. The congenital absence of premolar 2 in animals of known parentage informs the debate on the prevalence and aetiology of this trait in archaeological populations. Although osteochondrosis lesions are present, the frequency appears to be much lower in these females compared to the adult and immature males discussed in Chapters 2 and 3. This tentatively suggests that there might be some degree of sex-linkage in the expression of such lesions, which could warrant further investigation.

While the complete cow limb bones are obviously from extremely small cattle, it is unlikely that butchered articular ends within a large archaeological assemblage would be immediately obvious as expressing dwarfism, as seen for the metatarsals in Plate 4: 17, where it is not strikingly apparent from the morphology that the bones are from a dwarf cow in the absence of a scale. The presence of spavin in three, and probably all four, of these cows suggests that spending the winter tied in a byre is an equally plausible explanation for archaeological specimens as use for draught work. The presence on Kirstie's bones of all the stigmata, namely depression on horn core, eburnation in acetabulum, spavin, exostoses on metapodials and phalanges, particularly phalanx 3, commonly interpreted as evidence for the use of

archaeological cows for draught work indicates that this hypothesis is flawed (Gidney 2013). While these may be merely age-related degenerative arthropathies, the presence of features such as the exostosis on phalanx 3 in Keepsake but not Glenfinlet tentatively suggests that hereditary predisposition is a possible causative factor that merits further consideration. Since Sykes and Simmons (2007) have already demonstrated that the hypothesis linking grooving on the surface of horn cores with castration is false, these data begin to provide a body of evidence with which to challenge other currently popular hypotheses for the identification of castrates and working oxen.

4.4 Archaeological Evidence and Case Studies

In contrast to the ageing schemes weighted towards immature cattle seen in Chapter 3, the spectrum of older, old, aged and venerable animals are largely lumped together and summarily dismissed: "Roman sites in England have a reputation for producing bone assemblages dominated by adult cattle, and that seldom makes for interesting age at death analyses" (O'Connor 2000, 90). Such an approach misses out on swathes of information that might be discussed, such as attitudes to individual animals, rather than herds, ability to over-winter consistently, lack of murrain or catastrophic weather causing devastating mortality, value of lifetime dairy productivity, investment in rearing replacements, consumer or producer led demand for dairy produce compared to meat. The retention of breeding females to advanced age also impacts on interpretations of "improvement". An advanced generational interval will result in a slow change in genotype and phenotype. A high proportion of old cows can suggest a lack of desire or necessity for change.

A primary aim, when initiating the Dexter reference collection, was the acquisition of data to give broad approximations of calendar age for such older animals from tooth wear. The advanced age at death indicated by extreme tooth wear has been addressed by Jones and Sadler (2004, 2012), who separate elderly from adult cattle by examining the eruption of the cement-enamel-junction (CEJ) of the lower third molar. This is a promising method, though yet to be widely adopted. Counting incremental layers in tooth cementum to establish age at death is not a feasible option in commercial archaeology (O'Connor 2003, 158), though the technique has been trialled. For example, the analyses of tooth wear and cementum annulus counts for a

sample of 75 cattle mandibles from 1st – 2nd century AD deposits from Carlisle show a clear tail of elderly cattle slaughtered in excess of 15 years old (Rackham 1986b, 163-4). While there is no way to determine the sex of mandibles, such old cattle might be cows while the peak cull of 8-12 year old cattle could indicate the beefing of more oxen. Although these bones represent the victualling of a Romanised settlement, the most elderly cattle in late 1st century AD deposits could have been reared in an indigenous husbandry system with little or no Roman contact.

The earlier discussion of the possible association between smallholders and elderly cattle is pertinent here. Large estates, whether Roman villas or medieval manors, are always more likely to have had rolling systems of replacing cattle to minimise capital depreciation. The preponderance of mature to elderly cattle on Romano-British sites, noted above by O'Connor, is therefore of great interest in suggesting that cattle-keeping may have remained in the hands of the indigenous small scale farmers rather than being supplanted by large-scale villa estate farming by Romanised landlords. Since the archaeological evidence is of bones, there is a general assumption that these elderly cattle represent culls from rural herds supplying urban or military shambles. What is not usually considered is that these old cows could possibly represent culls from urban or military dairies, possibly with the old cows that were no longer holding in calf being milked for an extended lactation period prior to slaughter. In Carlisle, McCarthy (2002, 107) noted the prevalence of the strip building in *vici* and suggested an agricultural use for some as hay barns, without suggesting what the hay was to be fed to. Daniels (2002, 194-6) drew attention to the rural morphology of medieval boroughs in northern England and the grants of common pasture and shielings in the associated charters, concluding that a substantial agricultural component was necessary for the survival of such settlements. The provision of pasture and shielings indicate that the needs of cattle were provided for in the establishment of these boroughs.

This concept of the urban or military milch cow is particularly intriguing with regard to the large numbers of cattle bones found in association with Roman forts, for example Binchester, especially in the later phases when occupation continued to flourish in the absence of a supply of coinage (Ferris 2011, 117-124). Given the previously discussed value of milking herds in sustaining indigenous mobile raiding parties in later historic periods in Ireland and Scotland, and the suggestion that medieval vaccaries in upland regions may have similarly funded medieval lordships,

there would appear to be no inherent reason why the heirs of the late Roman army in northern England should not have adopted a similar system. This hypothesis would see cows as a render in kind, comparable to the cow for metreth noted in the 12th century Boldon Book.

For the later medieval-early post-medieval era, there appears to be a considerable time delay in the archaeological faunal record before evidence for specialised dairying becomes generally manifest, despite Walter of Henley and the associated treatises describing the management of vaccary cows in the 13th century. The range of disasters which befell the 14th century could have precluded widespread adoption of such ideas. However, during the 15th century the widespread occurrence of infant calf bones, discussed in Chapter 3, suggests increased availability of milk for human consumption. Possibly the advice in the didactic treatises records innovative practice for managers of large estates rather than traditional husbandry, which would not need to be written down for dissemination. As noted in Section 1, the presence of dairy cows is depicted in the art of the 15th century, with more abundant images of cows being milked and herds of cows with few (Hartley 1969, 72), or no (Pérez-Higuera 1998, 179), calves present. Where the prime function of the cow was to breed oxen for draught, the exploitation of milk from the cow was of secondary importance, as is still the case in India (Doornbos et al 1990, 185). There would therefore be a dichotomy between upland and lowland cow-keeping strategies, with the emphasis on pastoral dairy production in upland regions with access to summer pastures for vaccaries. This point is discussed by Winchester (2003) with regard to the vaccary site excavated at Gatesgarth, Buttermere (Railton 2009). The presumed expansion of cow dairies concomitant with the increase in calf bones may partly reflect the decline in demand for working oxen with the increased usage of horsepower. By the early 17th century, Markham could write of different types of cows for the dairy and for the butcher, rather than a spectrum within one population which may have been the case previously. This provides more background for the 16th century "improvement" or increase in size discussed in Chapter 2. Less emphasis is generally given to the fact that the small type of cow continues alongside the larger ones. What is also not discussed in depth is the fact that the two sizes of cattle may reflect parallel management systems. Large cattle are suited to large lowland estates with capital and hubandry by men. Small cattle are suited to small holders, particularly women, and upland grazing. It is singularly apposite that male analysts, such as Albarella and

Davis, are concerned with the identification of large "improved" cattle whereas this female author is more interested in the continuity of the small indigenous cattle.

Case Study 1: Neolithic slaughter patterns

In contrast to the archaeological evidence for aged cattle and a possible link to dairying discussed above, Vigne and Helmer's (2007, 26-32) discussion of the slaughter pattern for adult cattle from a range of Neolithic sites identifies a peak of cows killed at 4-8 years old, together with infant calf mortality and post-lactation calf slaughtering, as evidence for dairy based herding. This is an extremely interesting concept which deserves further consideration. The modern parallel to such a cow mortality profile is the Holstein-Friesian, kept under rather different production and husbandry systems but with a comparable mean slaughter age of 6-8 years (Sten 2004, 67). The slaughter of the Neolithic 4 year old females suggests beefing of heifers after the first or second calf, assuming fairly slow sexual maturity with primaparity as 3 year olds, while the 8 year olds may have produced, at most, five calves. Taken together with the two peaks of calf mortality, this scenario appears to deserve the term "improvement" with extreme selection pressure for desirable qualities. The high turn over of the breeding females would mean that no one cow would contribute a "founder effect" to the herd and drift in the genetic base of the herd would be rapid. Obviously the mere bones cannot provide information on selection for behaviour or dairy production but, assuming the interpretation of dairy herding is correct, such qualities as friendliness, standing to the pail, milk let-down, size of teat and teat canal for ease of hand-milking are all possibilities. Vigne and Helmer (2007, 26-8) take a rather minimalist approach to their own evidence, repeating that these early domestic cows would have needed the presence of the calf to stimulate milk let-down. A counter argument would be that any cow that failed to be co-operative with milking was beefed. Another possibility, since these Neolithic cattle were more closely akin to the aurochs, is that this mortality pattern represents the Ungulate Paradox, discussed in Chapter 2, whereby the "best" animals in terms of reproductive success have the shorter natural lifespan. No work has yet been done on applying MWS to aurochs mandibles to equate tooth wear with the life expectancy of the wild ancestor, so the norm is unknown. Size may also be related to longevity, both the Neolithic cattle and the Holstein-Friesian are larger than the Dexter cows, who demonstrably have longer

productive lives. Selection for longevity could therefore have inadvertently resulted in diminution.

Case study 2: Possible evidence for dwarf cows

The identification of dwarfism in archaeological cattle has not attracted consideration, despite the consistent small stature recognised from later prehistoric to early modern cattle bones.

One outstandingly small Romano-British cow with an estimated withers height of 0.75m, using the average of Zalkin's factors, was identified by Middleton (no date, 24-5) at Bainbridge Fort. Such a tiny animal has to have been the product of genetic dwarfism. Middleton's comparison of cattle withers heights from Catterick, Bainbridge, The Lanes at Carlisle and Ribchester demonstrates a constant presence of cattle less than 1m tall, with a peak in the range of 0.95-1.05m at Ribchester. Analogy with the Vycanny cows indicates that some of these smaller cattle could potentially be expressing genetic dwarfism. Similarly, Figure 4: 6 shows that withers heights calculated by the same factor for metapodials from Vindolanda (Rayner 1999) and South Shields (Winship 1996) include two examples of particularly small individuals from South Shields.

The small size of some cattle metapodials from medieval deposits at Tuthill Stairs, Newcastle upon Tyne (Archaeological Services 2007a) also suggested the possibility of the presence of a form of dwarfism, though no complete metapodials were recovered for estimates of withers height. An example of such a metacarpal from Newcastle is depicted in Plate 4: 17 compared with one from the Vycanny Dexter cow Glenfinlet, known to be a dwarf. The archaeological bone is more gracile than the Dexter. This medieval bone was submitted to the laboratory that tests for the presence of chondrodysplasia in live Dexter cattle and a negative result was returned. This merely means that the gene responsible for dwarfism in the Dexter was not present. As seen in Chapter 3, different breeds have differing causative genes for chondrodysplasia.

Case Study 3: Possible vaccary cows at Green Shiel, Lindisfarne

It is difficult to make unequivocal identifications of dairy cows purely from archaeological bones. However, the excavations at Green Shiel, Lindisfarne (O'Sullivan and Young 1991) produced articulated cattle skeletons with female

morphological characteristics (Scott 2000, 17). Since these burials were associated with large numbers of infant calf bones (Scott 2000), discussed in Chapter 3, it is possible that Green Shiel operated as a vaccary and the adult burials represent fallen stock. While Scott (2000) failed to record the adult burials as individuals, the metrical and ageing data from adult bones are clearly recognisable in the data tables among the otherwise juvenile assemblage. The bones of two adult individuals, GS91 "Lucy" and LSF91 386/91, are clearly boxed as such in the archive currently held in the Department of Archaeology, Durham University. However, neither is a complete skeleton despite the fact that one complete articulated skeleton was photographed *in situ* (Scott 2000, 17). The appellation of "Lucy" by the excavators is of interest with regard to the previous discussion on the bestowing of Christian names on cows. This skeleton has mostly hindquarter bones surviving, with patches of eburnation on both left and right femoral heads. The corresponding acetabula do not survive. The right maxillary molar 3 has the "hook" on the posterior cusp described for the modern Chillingham bull in Chapter 2 and discussed by Ingham (2000, 171-2, Figs 5-6) as a contributory cause of death in the Chillingham herd. Age-related degeneration would appear to have contributed to the mortality of "Lucy". 386/91 is represented mainly by forelimb bones but these do not appear to derive from the same animal as "Lucy". A suite of minor OC lesions is present on the distal radius, proximal metacarpals, first and second phalanges. An age at death beyond c. 4 years is indicated by the fused distal radius. Exostoses are present on the proximal metacarpals, corresponding to Stage 3 as defined by Bartosiewicz *et al* (1997, 35). The right metacarpal has expansion of the distal lateral condyle, mirrored in the articulating first phalanx. It can be seen that 386/91, like the Vycanny cows, exhibits morphological changes in the feet which mimic those seen in modern draught cattle.

The tooth wear stages recorded by Scott (2000, 100), Table 4: 4, indicate that the Green Shiel cattle had less advanced tooth wear than the Vycanny cull cows, Table 4: 2, and that there are younger and older animals present.

There is a significant disparity between the withers heights calculated from the data in Table 4: 5 by Scott (2000, 57) and this author, though the same factors are stated to have been used. For the Vycanny cows, the average of the factors for the metapodials of cows and steers produces a good match with the known heights of the live animals in Table 4: 3a-d, so only these factors have been applied to the Green Shiel metapodials in Table 4: 5. The estimated heights from the humeri in Table 4: 5

show an overlap with the results from the Vycanny Dexter cows in Table 4: 3a-d. However, the height estimates from the Green Shiel femora and tibiae indicate slightly taller cattle than the Vycanny Dexter cows, though still small in absolute terms. The Green Shiel cattle in life were obviously very small in stature but not as small as the dwarf Vycanny cows. The range of height estimations in Table 4: 5 would be considered acceptable in modern non-short Dexter females. Scott (2000) did not record measurements of the distal humerus trochlea or the distal tibia. LSF91 386/7 has both humeri present while GS91 "Lucy" has both tibiae present. While this is obviously too small a sample to draw conclusions from, the Green Shiel humerus in Figure 4: 7 lies outside the Vycanny cow range while the tibia in Figure 4: 8 lies with the Vycanny cow range. Though these are the commonly surviving and measurable archaeological fragments, neither demonstrates the visual difference between the robust Dexter bones and gracile Green Shiel bones seen in Plates 4: 18 and 4: 19. The Green Shiel tibia closely resembles a specimen from a recent Chillingham, Plate 4: 20, with the disparity of size reflecting the dimorphism between female and male. The small and gracile bones from the adult cattle at Green Shiel further indicate that these were females. These cows may be envisaged as ancestral in appearance to the original medieval Dun Cow sculpture, discussed in Section 1.

4.5 Discussion

This chapter has considered some of the historical evidence for dairy-based cow keeping and the results suggest that the productivity of small cows, relative to the inputs required, is severely under-estimated in interpretations of archaeological assemblages. This is articulated by Doornbos (*et al* 1990, 160) for modern India where crop farming has priority over milk production. Working animals are considered more important than milch cows and therefore have first claim on feed and fodder resources. Milk production is attractive where the cows can be sustained on crop residues, waste materials and communal grazing. Out of pocket expenses for milk production are avoided while the sale of surplus milk or *ghee* provides cash income. This type of traditional dairy cow keeping was still prevalent in 19th century Ireland, where it attracted derogatory comment by Pringle (1872, 60) who was of the "improving" opinion that if the cows should be fed "cake or other artificial food, there is little doubt that the money so expended would be found a profitable investment". In

fact detailed Indian cost benefit analyses of such approaches to "improvement" demonstrate what the rural poor have always understood, that such investment is not profitable on a small scale. The profit at this level is of the "something for nothing" type, converting waste into a commodity with cash value. The attitude of both the post-medieval "improvers", and some zooarchaeologists, to the small dairy cow scraping a living from the waste reflects George's (1985, 294-5) indictment of modern dairy planners in India, who "make little distinction between milk producers and milch cows, perceiving – and treating – them both as unintelligent beasts who must be patiently conditioned and constantly prodded by higher forms of life", concluding that "there are others beside peasant milk producers to whom enlightenment is long overdue and whose notions and sentiments urgently require shedding". These higher forms of life include commentators on historic dairy yields based on the volume of liquid milk produced for the days in milk. As George (1985, 296) points out, it is the butterfat content that is of interest to the peasant producer who calculates yield by the volume of *ghee* per animal per lactation, using these data to inform breeding decisions on the choice of bulls.

The suggestion that assemblages dominated by bones from adult cattle do not have the potential for interesting analyses and interpretations needs to be not only challenged but rebutted. The modern examples of aged Dexter cows demonstrate that very aged cattle can represent much more than cash on the hoof. The notion that those beasts that have provided for us should themselves be provided for in their decline is still part of Hindu and Jain religious ethos, notably the popular concept of the "Holy Cow". Other religions through time have placed similar importance on the dairy cow and her milk and this again may be one part of the reason for the prevalence of elderly cattle in Romano-British assemblages. These old cattle may have been in some sense companion animals, as well as economic providers, who had earned a retirement before the inevitable ending. Such a concept could be particularly appropriate for the Green Shiel cow burials, if this was a vaccary run by, or on behalf of, a Christian religious community with a vegetarian ethos. The notion that bestowing a Christian name on a cow bestows an identity on it, comparable to a godchild, which places it outside the human food chain (Fabre-Vassas 1997, 85) is a further possible explanation for the burial of cows at Green Shiel, beyond mere old age and disease.

Sykes' (2007, 52) observation of a correlation between eras of political instability and warfare, for example Iron Age and post-Roman, and diminution in the

size of cattle needs to be more widely considered in terms of the respective risks of arable and pastoral strategies. Crops remain in one place and are vulnerable to trampling and burning. Cattle are mobile. Cows can travel with a war band as a victualling unit on the hoof and, if driven off as prey, have the potential to be recouped by a retaliatory raid elsewhere. The concept of the small cow as a mobile war chest, funding and feeding a host, needs broader consideration outside the last bastions of the practice in Ireland and Scotland.

Of ongoing interest to international Dexter breed societies is the potential to breed cows with a withers height about or less than 1m without using the dwarf gene to achieve such a small stature. The contrast between the robust Dexter bones and gracile archaeological bones suggests that this was possible in the past. However, the presence of occasional examples of exceptionally small cattle suggests that a form of dwarfism may still have been present within the population of archaeological cattle. This could only descend through the female line and would be a rare occurrence, if no bull carrying the gene was used for breeding. These rare tiny cattle also show that such female calves could be tolerated and reared. Ancient DNA analysis of the small and tiny cattle bones could potentially resolve the question of the presence of dwarfism in these archaeological cattle and, if present, the particular gene responsible.

The four Dexter dairy cow skeletons demonstrate that the suite of arthropathies found in modern draught cattle are also present in cows that had never been used for draught work. This serves as a cautionary example that there can be no simple identification of draught cattle from archaeological finds of such arthropathies, particularly on the pelves of females. These four chondrodysplasia carrier cows also demonstrate that recognising the condition in a fragmented archaeological assemblage would not be straightforward, though the malformed articular surfaces of the astragalus might be the most diagnostic feature to record.

Traditional breeds of cattle were originally multipurpose, serving the pail, the yoke and the shambles equally. Yet within these breeds it was, and is, perfectly possible to have a spectrum of phenotypes, including at one extreme “classic” dairy conformation. The modern Dexter serves as an example, with a dairy emphasis in the mid 20th century, Plate 4: 1, and a beef emphasis in the early 21st century, Plate 4: 21. This range of versatility within one local type of cattle would have the potential for a rapid response to the changing fortunes of “Up Horn, Down Corn”, or cows for the dairy and oxen for the yoke. Modern specialised dairy breeds would be incapable

of such a response. In contrast, while dual purpose breeds can include extremes of dairy or beef conformation, they are not constrained by them. There is no need to invoke terms such as “improvement”, “degeneration” and “retrograde” to explain swings in the popularity of small gracile dairy cows. Rather, such peaks of popularity should be discussed in terms of the contemporary socio-economic background to ascertain why the dairy type was currently profitable. The breeding cow, beef type of cow and the end use of the dairy cow for beef will now be considered in Chapter 5.

Chapter 5. The Cow: Beef

There are two themes to this chapter. Firstly, the end use as beef of elderly cows culled from the dairy, or vaccary, and breeding, or demesne, herds, discussed in Chapter 4. Secondly, the concept of the cow as a suckler, not a milker, rearing calves primarily to be consumed as beef, not veal, rather than kept as herd replacements or draught animals. The cull dairy cow and the suckler cow herd are two contemporary cattle keeping strategies for the supply of beef. The supposed antiquity of the latter practice will be considered here. An underlying assumption into the later 20th century was that Neolithic cattle were domesticated as a convenient source of beef on the hoof, to obviate the necessity of men hunting, with calves allowed to remain on their dams and grow into beef cattle. Hence the concept arose of a "Secondary Products Revolution" (Sherratt 1981), using cattle for draught and dairy, subsequent to the initial "Neolithic Revolution" of domestication (Childe 1936, Cole 1970). As seen in Chapter 4, such models are no longer tenable.

As seen in Chapter 4, suckler cows included cows as breeders of draught oxen, with both cows and offspring eventually supplying beef when culled. Historians understand that the prime purpose of the breeding herd could be the production of bull calves for haulage (Thompson 2005, 135) and this notion is percolating into zooarchaeological thinking (O'Connor 2010, 8 & 10). A less common suckler herd strategy is that of the herd breeding bulls destined for the sports described in Chapter 2. Here, another aspect of sporting cattle will also be considered, that of the cow "wrestling match" and the resultant selection pressures on cow phenotype.

The conformation of the 20th century ideal beef cow differed from that described in Chapter 4 for the dairy cow. Both the topline and underline should be straight and the legs straight and short, giving a rectangular, rather than triangular, outline. There should be good depth of body, with a long, broad rump, well-barrelled ribs and thickly fleshed thighs. The head should be short and broad (Gerrard 1945, 27-8). Plates 4:1 and 4: 21 illustrate the difference between the extremes of dairy and beef phenotype in the Dexter and demonstrate that both types may be present within one genotype.

The eating quality of beef from mature cull cows will be considered from the surviving historical recipes and the meat from the Dexter cows in the reference

collection. These cows were all suckler cows, sourced from herds with breeding mostly unrelated to the Vycanny cows in Chapter 4.

5.1 Historical Information

As discussed in Chapter 4, the majority of the medieval and 16th-17th husbandry texts presuppose management of dairy cattle. However Markham (1616, 88) does explicitly state that "the use of the cow is twofold, either for the Darie or for breed". The implication of "for breed" appears to be the breeding of replacements for the dairy herd or the breeding of oxen. While the latter approach begins to foreshadow modern single-suckled beef herds, the beef is still secondary to the yoke. The calves to be reared are still only those born between September and February, outside the main cheese-making season. Suckling these autumn and winter born calves released the dairy maid for other labour, such as threshing, over the winter and gave the calves enough nourishment to winter well without other supplementary feed. The suckler cow, at this time, would appear to be still one aspect of dairy enterprise, rather than a beef producer in her own right. This is in accord with the 14th century account roll evidence from Barnard Castle (Austin 2007, 105) for a leased dairy herd and a breeding desmesne herd, discussed in Chapter 4.

Chapters 3 and 4 discussed the sources for calf-rearing in relation to vaccary cows. The quantity of surviving information is probably in inverse proportion to the application of these ideals in real life. The simple option of allowing the cow to rear her calf is so basic that it rarely warrants mention in surviving husbandry texts. Markham (1616, 88) presents two methods of calf rearing, of which one is to "let them runne with their Dams all the yeere, which is best, and maketh the goodliest beast". This suggests that, by the 17th century, the practice of single suckling calves was commonplace, at least for rearing herd replacements.

Markham (Best 1986, 166) makes it plain that the end fate of the dairy cow was the shambles. The reasons given for culling dairy cows are either age or mischance. This is one instance where large size is seen as a virtue as the larger cow, after feeding, will leave more profit to buy a replacement cow for the dairy.

Some decisions on culling were made externally to the individual herd. As described in Chapter 4, cattle raiding was an integral part of the fabric of early medieval society. In Ireland, actually killing or maiming cows was regarded as

unsporting and legislated against. Raids that killed or maimed cows wantonly were acts of war, designed to diminish the capital assets and potential for retribution by the aggrieved party (Lucas 1989, 188-193). The disbursement of cattle taken as prey to the royal household officers in the Welsh Laws of Hywel Dda includes only one mention of cow rather than steers, young stock or bull (Wade-Evans 1909, 165). No such niceties appear to have applied to the Anglo-Scottish border reivers of the 16th century. Cross border raids were warfare. The summer shielings on the high pastures were the herders' "chiefest profit" (MacDonald Fraser 1974, 36) but the staple foods are described as beef and broth in quantity or porridge with sodden meat (MacDonald Fraser 1974, 35). Obtaining such meat was the purpose of the reiver. The vaccary cows of the shielings were stolen for beef.

i. Natural Mortality and Casualty Slaughter

As indicated by Markham's "mischance", some of the mortality of adult cows may have been casualty slaughter or salvage of fallen stock. Archaeological interpretations rarely consider that in-calf cows could be killed for beef. In fact, as seen in Chapter 3, most of the modern veterinary studies of foetal calf development have collected such foetuses from abattoirs. This reinforces the concept that the calf itself is of little or no value compared to the milk yield of the cow. In the absence of modern veterinary remedies, the normal response to an ailing cow was casualty slaughter to salvage some value from the carcase rather than suffer a total dead loss. For example, in the 18th century cattle suspected of having contracted cattle plague were driven straight to market to be sold before they came valueless, incidentally spreading the contagion (Broad 1984, 108).

One metabolic disorder that still causes loss of cows is hypomagnesaemia, commonly known as staggers or grass tetany (Straiton 1964, 22-4). The compact bone structure of adult cattle can store only a few days worth of magnesium reserves and there is a gradual decline in such reserves during the winter. The combination of low reserves at turn out in spring onto lush grass with low magnesium content can be rapidly fatal, as Tusser was aware in the 16th century (Hartley 1969, 125). Hypomagnesaemia can also be triggered in out-wintered, in-calf or lactating females during sudden cold spells (Straiton 1964, 22-4), conditions applicable to archaeological cows. While today the condition can be treated by subcutaneous injection of magnesium solution, the interval between symptoms becoming apparent

and death can be still too short for effective treatment. No remedy was available in the past.

The major reason for culling cows, both now and in the past, is mastitis. The Welsh law codes make it clear that the sale of a cow with a blind quarter involved an ongoing annual compensation payment for the loss of production from the teat (Wade-Evans 1909, 218). It would appear that one blind quarter could be tolerated but loss of another quarter would be reason for culling. Black garget, or gangrenous mastitis, is a particularly virulent type that was often fatal and difficult to treat. The traditional response was slaughter for salvage and Straiton (1964, 102) highlighted that modern meat inspection meant that this was no longer an option. Summer mastitis, or "August Bag", chiefly affects dry cows from July-September. Prior to antibiotics, there was no effective treatment so such cases would also have entered the human food chain. The traditional preventive was to have few, or no, cows dry during the vulnerable summer period (Straiton 1964, 116), though maiden and in-calf heifers remain at risk.

Another common type of cull cow is the geld cow or barrener, who fails to hold in calf. A proven breeder in poor condition who missed calving for one year could be tolerated for the sake of the enhanced lactation subsequent to a long dry period. However, the cow or heifer that regularly comes bulling but fails to hold to service may have cystic ovaries. While this condition can respond to veterinary intervention, it is not always successful, as in the case of the heifer Dusty in Chapter 3. There would have been no effective remedy in the past.

The cow that went lame over winter and was therefore unable to walk to the upland summer pastures would also be a candidate for slaughter. An example of such a condition is discussed below in the Dexter reference cows.

As the example of black garget shows, meat from some of the casualties described is not considered fit for human consumption today, though attitudes were different in the past.

ii. The Eating Quality of Cow Beef

In contrast to the meat of dubious quality from these casualty cows, maiden heifer beef was generally considered to be the finest quality. Cows that had produced up to three calves were thought to produce acceptable beef but after the third calf, carcase quality was thought to deteriorate (Gerrard & Mallion 1977, 301). Cow beef

was generally boned out for processed products, such as pies, but sold by urban butchers where cheap meat was in demand (Gerrard 1945). The quality of prime beef and cull cow beef is, however, not necessarily reflected in the value placed on the meat. For example, in July 2012 a top price of 218p/kg was achieved for OTM cows compared to 193p/kg for finished cattle (Northern Farming Gazette 270, 3).

As noted in Chapter 4, bones representing beef from mature to elderly cattle, including a high proportion of females, are well evidenced on archaeological sites, such as Roman forts (O'Connor 2000, 90). Modern opinions on the eating quality of such old cow beef tends to be informed by modern methods of cookery and expectations of taste and tenderness, without considering whether these are applicable to the past. Cool's opinion (2006, 85-7) of the beef supplied to Roman towns is that it "would probably have been rather tough", though "providing it was cooked with care, the beef could well have been tasty". While it is an unknowable proportion, no distinction is generally made between the supply of beef from casualty slaughter and planned culling. The former might indeed be poor quality meat, depending on the time of year and condition of the animal. The latter could be extremely good quality meat, depending on the skill of the grazier. The advice received by the author from traditional butchers on finishing old Dexter cows was to get them thin **then** fatten them. The beast lays down a new growth of muscle tissue, therefore it is not tough meat when butchered. Such knowledge and practice is part of the art and mistery (*sensu* medieval) of the butcher/grazier.

The modern concept of "prime" cuts is in fact wholly irrelevant to medieval, and earlier, mindsets and methods of cookery (Rogers 2004). Modern cultural conditioning needs to be discarded to understand the medieval approach to the beef carcase. Collingwood's (1966, 282-3) definition of re-enactment is relevant here, to look at the topic from the medieval viewpoint. Scully (1995, 40-65) considers the contemporary medieval theoretical bases for medieval food and cookery, also summarised by Redon (*et al.* 1998, 110):"search as you may through medieval cookery treatises, English or French, you will not find a trace of 'roast beef'". Beef was considered to have a 'cold' and 'dry' humour, therefore a 'gross' meat good only for boiling: gross in the sense that it lacked the subtlety or finesse needed by nobles, who lacked the digestive powers of peasants and others who engaged in heavy labour. However, defining beef as a gross meat in the 14th-15th centuries partly reflects an increase in beef consumption by the lower social orders (Woolgar 2006, 90) and the

aristocracy emphasising exclusivity by consuming poultry and game (Woolgar 2006, 92).

If there was no roast beef, there could be no concept of prime roasting joints. This in itself demonstrates a totally different approach to the relative value of different parts of the carcase, which impinges on the interpretation of cattle bones recovered from medieval sites. However, it should be borne in mind that the extant cookery treatises largely detail late 14th and 15th century dishes served to the gentry. The very fact that these recipes were written down as culinary *aides memoires* indicates that these were not dishes for every day consumption. There is no recipe for boiled beef as this was daily fare that everyone knew how to prepare. Hieatt (1980) was one of the first authors to consider medieval recipes on their own merits, without the negative preconceptions so prevalent in Mead's (1931) discussion. However, while Hieatt noted the culinary subtlety of Anglo-Norman cookery compared to contemporary French cookery, the prevalence of boiled beef and absence of roast beef continued to be attributed to the poor quality of the available beef. Hieatt (1980, 298) still considered beef in terms of "choice cuts" and "tougher cuts" rather than the medieval distinction between "gross meats", such as beef, mutton and bacon and more dainty viands, such as sucking pig and poultry. Viewing beef as a "gross meat" makes sense of the strawberry and cherry sauces for boiled beef described by Hieatt (1980, 296-8), highly spiced with "warm" spices such as ginger and sugar. In medieval thinking, such "warm/moist" sauces would neutralise the "cold/dry" quality of beef for the delicate digestions of the nobility.

Medieval thinking differentiated, as we do today, between the meat from young and old animals. However, the concept then (Scully 1995, 47-8) was that the flesh of young animals was "moist", while meat became progressively "drier" with the increasing age of the animal. The amount of fat carried by the animal could also increase its "moistness" and females were generally considered to be more moist than males because of the higher fat content of the carcase. Castration was seen as a method of prolonging the moistness of the young animal and was a desirable practice as the meat from aged entire males could become too "dry" to be healthful eating, as seen in Chapter 2. Such concepts need to be taken into consideration for the interpretation of sex and age structures of slaughter populations.

Furthermore, the doctrine of the humours is rooted in classical antiquity, with authors such as Galen, and was promulgated in the 6th century AD dietary

recommendations of Anthimus to Theuderic, King of the Franks (Grant 1996). In this text, beef should first be steamed before any further method of cooking is employed (Grant 1996, 51). This is another instance where seeming superstition has practical validity. Both Hartley (1985, 187) and Spry (1972, 634-5) give recipes where meat of dubious tenderness is given a preliminary steaming or simmering before continuing with the standard preparation of whatever dish is required. If such double cooking was a routine technique for preparing beef, according to the logic of the time, then the result would be tender meat, whatever the age and finish of the carcase. In this instance, the art and mistery of the cook complements that of the grazier. The cook of large households was also the butcher, as is made clear in the Welsh law codes (Wade-Evans 1909). Rather than dealing with the anonymous lumps of meat of the present day, the cook in the past would know exactly the condition of the beasts presented at the kitchen door for slaughter and would plan the amount of cooking needed accordingly.

In summary, the sources indicate that cattle for meat could have fallen into broadly similar rankings to those seen today but for very different reasons. Veal was a desirable food. Sub-adult cattle were seen as prime stock. Females were superior to castrates but the latter were preferable to entire males. The prejudice against aged entire males was not extended to aged females.

Two points are therefore pertinent to the archaeological interpretation of assemblages dominated by bones of adult female cattle. Firstly, for the meat to be perceived as desirably "moist", it needed to be fat. This in turn implies that the cows sent for slaughter had been fed to the required standard of "finish". Secondly, the absolute age of the cattle was not as important as the sex and the fat cover. From the perspective of quarter-master to a military establishment or achator to a noble household, well-finished beef from older cows may have been viewed as more desirable than equally well-finished beef from younger oxen. Woolgar (2006, 91) comments that "seigneurial husbandry was geared to supplying the best-quality meats for the household, dispatching poorer stock to market". Statements such as "bones of cattle assigned to the mature and elderly categories represent individuals well past the age when they would have produced prime beef" for the Flixborough assemblage (Dobney *et al* 2007, 140) demonstrate a lack of understanding of such contemporary attitudes to beef carcases. Questions such as "why were the aristocracy apparently settling for the old beasts whilst at the same time provisioning the *wics* with prime

aged animals?" (Dobney *et al* 2007, 141) may possibly be answered by such a concept of well-finished old cow beef being of superior eating quality to younger ox beef. The supposedly "prime" beef from younger cattle supplied to the *wics* could in fact have included poor quality beef from casualty slaughter beasts. It can be seen that a simple linear correlation between age of animal and eating quality of meat still pervades zooarchaeological thinking. The distinction made by those selecting stock on the hoof for slaughter or sale would be between plain and finished beasts, irrespective of calendar age.

The remaining type of cow beef is that stolen on a cattle raid. The border tradition is that the lady of Harden would send to table a dish containing a set of spurs when the larder was empty (Scott 1931, 60). While a fat heifer might be preferred, in practice hungry men would slaughter and cook a cow as soon as safe from pursuit, irrespective of stage of lactation or pregnancy or "finish". In the ballad "Dick O' the Cow", the eponymous Dick on a hot trod to recover his three cows is captured by the reivers who offer him "a piece o' thy ain cow's hough" but "Dickie's heart it grew sae grit, that ne'er a bit o't he dought to eat" (Scott 1931, 193-4). The implication here may be a reluctance to eat the cow known personally but the anonymous stolen cow was acceptable beef. The inaugural raid of a new chieftain would have provided the wherewithal for the associated feast of accession. The post-medieval chief of Clanranald, returning to take possession after an education away, was deposed in favour of his brother after failing to appreciate the profusion of cattle slaughtered in celebration (McHardy 2004, 20-1). Such raids and feasts are another aspect that might be considered in the interpretation of the cattle bones from such sites as Flixborough (Dobney *et al* 2007).

iii. Artistic Representations

While the medieval cookery texts deemed it unnecessary to describe the boiling of beef, the importance of this staple food is indicated by the vast cauldrons necessary for boiling large joints of meat depicted in scenes of cookery in medieval art. Examples from the 14th century include the Luttrell Psalter (Backhouse 2000, 12) and MS 264 Bodleian Library, Oxford (Hammond 1993, 66 & 98). The cook is identified by the flesh hook necessary to remove such joints from the cauldron (Henisch 1976, 187). In contrast, there is an absence of depictions of either cows suckling calves older than *circa* 8 weeks old or of cows being slaughtered. This

reflects the preoccupations of the wealthy patrons commissioning such artwork. Large cauldrons of simmering meat reinforce the resources for hospitality on a grand scale of the patron. As seen in Chapter 4, the red heifer with calf has a religious significance and the vaccary cows are a statement of a source of cash income that fall within the annual calendars of work. The suckler cow and the cull cow do not fit within such frameworks of allegory, financial stability and seasonal labour and so are not a subject for art any more than boiled beef was the subject for a recipe. However, in the Luttrell Psalter there is a tantalising hint that the division between species for milk production and draught, previously noted for modern India, may have been current in 14th century Lincolnshire. The milking bail is populated by sheep (Backhouse 2000, 30) but the only cattle shown are oxen and a bull (Backhouse 2000, 16-17 & 34). There is a conspicuous absence of both cows and calves, suggesting that cows were not kept on Sir Geoffrey's manor and that the oxen were bought in.

In subsequent centuries, the suckler cow also failed to attract the attention of patrons and artists. Hall and Clutton-Brock (1989, 56) comment that a mid 19th century painting of a beef shorthorn cow and calf "is unusual in that a beef cow is depicted with her calf". The most notable painting of this genre is Landseer's family group of Chillingham bull, cow and calf (Hall & Clutton-Brock 1989, 46), which emphasises the "wildness" of the Chillingham cattle. Johns (2011, 115) illustrates a Japanese ivory carving of a buffalo cow with a calf having horns nearly as long as its ears. Even this is of 18th or 19th century date and the author has failed to find any published representation in earlier Western art of a calf with comparable horn development in association with its dam. It would appear that the concept of the suckler cow was not associated with the financial return of her dairy colleague and so did not warrant artistic commemoration.

One outstanding example of an elderly cull cow did merit artistic record. Of great interest for the topics of longevity and human attachment to cows of advanced age, considered in Chapter 4, is the painting of "Starling of the true Norfolk breed in the 36th year of her age" (Hall & Clutton-Brock 1989, 84). Starling is shown dry, the udder appears to have been dry for some time and the cow does not appear to be in-calf, but otherwise the cow is in remarkably good condition for such an advanced age. The Dexter cow in Plate 4: 7a, Parndon Green Finch aged 29, clearly shows her age. Nothing more is known of Starling or the artist but the very commissioning of the

painting indicates the attachment of the owner to a cow with no capital value beyond the hide and meat price.

The female beef cattle which attracted the attention of patrons and artists were the fat heifers, particularly improved Shorthorns, of the late 18th and 19th centuries. These heifers were for exhibition, rather than breeding. The Craven Heifer, for example, "was four years old in March 1811 and is still in a growing and improving state" (Spargo 1988, 87). Such heifers were given geographical appellations, the Wensleydale Heifer is another well-known example, rather than the personal names of the milking cows. Depictions of cows with well-grown calves at foot become more frequent about 1850 (Spargo 1988, 120-121), indicating how recent is the concept of the suckler cow rearing a calf solely for beef. These cows and calves are depicted with the gentleman farmer, rather than the dairy maid of earlier art. The change over in cow management from the dairy cows managed by women to the suckler beef herd run by men has been discussed by Gidney (2009, 42-3). The male settlers of the later 18th and 19th centuries, who established the cattle ranches of the Americas and Australia, created the current concept of the range suckler cow herd rearing calves to grow into beef. Dairying was not a viable option on such ranches (Heinlein 1959, 68-9).

iv. Cow Sports

Equally modern, but appearing of greater antiquity, is the *Combat des Reines*, a bovine wrestling match which exploits the instinct of dominant cows to maintain or increase their social ranking when confronted with an interloper. It appears to have originated in the Alps as an informal rural spectacle at turn out in the spring, when each herd established the social hierarchy and dominant cow for the year, before ascending to the summer montane pastures. The Zanfara herd has a similar brief, but exciting, power struggle at turn out, Plates 5: 1a-d. A similar scenario might be envisaged for the vaccary cows in Chapter 4, when ascending to summer hill grazing.

The Herens breed of Austria/ Switzerland is the main participant in the *combat des reines* and is comparable in size and appearance to the larger, beefier Dexter cow, having a height range of 1.18-1.28m and a live weight of 480-800kg (www.raceherens.ch). The breed is described as triple purpose, being kept for beef, milk and female combat, rather than draught or male combat. Average milk yield in 1975 was estimated at 2909kg (c. 640 gallons)

(www.ansi.okstate.edu/breeds/cattle/herens/index.htm), compared to the average 428 gallons seen for the Vycanny herd in Chapter 4. The herd leader is known as the *reine*, hence *combat des reines* when two leaders engage in a power struggle. Though giving the appearance of antiquity, especially when staged within a Roman amphitheatre, such as Martigny, the current sport as a commercial and public spectacle appears to have arisen as a money-making enterprise during the Depression of the 1920's, a rather different approach to the concept of the "cash cow" but demonstrating the innovative responses of cow keepers and a rarely considered selection pressure on breeding cows.

The behaviour of the Herens breed was compared with another Alpine breed, Brune des Alpes, where the cows are not used for this combat (Plusquelle & Boissou 2001). The results showed a range of both behavioural and hormonal differences between the two breeds, reflecting the enhanced dominance ability of the Herens. Obviously, selection for such traits cannot be tested for archaeological finds but this example shows that selection for aggression can be a feature of breeding female cattle that are also milked and are of beefy conformation. The presence of enhanced testosterone levels in the Herens cows, combined with the stocky, beefy build, might possibly be reflected in the skeleton by robust bones with more masculine appearance.

The Herens calves retain the aurochs colouration, being red at birth then turning black with a red topline at about six months old (www.raceherens.ch). The deliberate selection of the feisty temperament of the Herens cow with this coat pattern may be coincidental. In terms of prehistoric utilisation of cattle, it is of interest that a breed with enhanced intra-specific aggression is still readily milked.

As seen in Chapter 4, the robust build of the dairy Vycanny cows' bones compared to the gracile bones from the medieval cows at Green Shiel suggests that the Dexter could be readily selected for the build of such a combat breed.

5. 2 Data from Modern Herds

i. Population dynamics of the herd, feeding and housing over winter

Chapter 4 considered the net annual food calorie balance of the dairy cow. Here, the fluctuating body weight and food intake of the suckler cow will be considered with regard to seasonal meat yield. As a proxy for cattle out wintered without supplementary feed, the Soays on Hirta give an indication of the annual cycle

of weight loss and gain for a population of feral sheep (Doney *et al* 1974, 102). In adult females about 20-25% of body weight is lost over winter (Grubb 1974, 268), despite the growth of the lamb *in utero*. Ewe body weight affects not only the ewe's survivability but also that of her lamb/s, more than the birth weight of the lamb/s. The heavier ewe has more reserves to maintain lactation. Traditionally managed cattle followed a similar cycle of weight loss and gain. Duckham (1963, 276) sums up interpretations of wintering cattle in the past "most of us have heard stories of the days when, at the end of winter, housed cattle were so weak from starvation that they had literally to be lifted out on to the grass in spring."

However Duckham's example is of store cattle, castrate males, and the bullock yard is a post-medieval phenomenon designed to produce fertiliser for arable land. Mulville *et al* (2005, 179) consider that "stalling is as yet unproven on any Atlantic Scottish site before the post-medieval period". The feral cattle on the Orkney island of Swona show that it is perfectly possible for cattle, as well as sheep, to survive in such marginal environments without supplementary winter feed or shelter (Hall & Moore 1986).

Duckham's example (1963, 277) illustrates part of the annual cycle of body weight with the results of feeding cattle of 500lbs liveweight on low, medium and high planes of nutrition for 24 weeks over winter, followed by 12 weeks on grass at spring turn out. Those on the low plane lost weight in the first 3 weeks of winter, stabilised body weight for the next 15 weeks then recovered to the original body weight. In the 12 weeks on grass, body weight rose from 500lbs to 780lbs, which is an increase of more than half the original body weight. The cattle on the medium plane turned out at 610lbs and reached 840lbs after 12 weeks on grass while those on the high plane turned out at 760lbs and reached 880lbs at 12 weeks. It can be seen that the cattle fed on the low plane of nutrition produced the greatest return of beef for the input of fodder. Where profit, rather than quantity of product, is the main consideration, it can be seen that the low plane of nutrition would generate the best return on the winter keep. Understanding this cycle of body condition is integral to the mistery of husbandry, determining the quantity of fodder to make and when the cull cow was fit to kill. Applying this principle to cows rather than store cattle demonstrates how in-calf females could lose body weight over winter despite the growth of the calf. The example given by Duckham is relevant to the Dexters and archaeological cattle of Dexter size as 500lbs (227kg) falls within the cow weight

range of a desired average of 650lbs and maximum of 800lbs when short-legged Dexter cows were the preferred standard type. It can be seen that the thin cow, below the breed average weight at turn out, could be in peak body condition at the top end of the breed weight range after 3 months on spring grass. This demonstrates the pitfalls of interpreting carcase weight from bones without knowing the season of slaughter and probable finish of the animal.

Study of the Soay sheep has thrown up another point of great relevance to cattle herders, especially in marginal environments. "The rate of increase of a population can decline when increasing population density reduces the condition of the adults, for then ovulation rate, conception rate, fecundity and neonatal survival rate are also reduced" (Grubb 1974, 269). Mulville *et al* (2005, 179) consider that lack of grazing would not have been such a constraint on herders to require the observed level of archaeological calf slaughter. The contrary argument is that the communities in question had a profound understanding of this concept, demonstrated by later historical evidence for manorial court paines actively restricting the headage of stock kept by each tenant to the amount of winter fodder that could be made, rather than the availability of summer pasture (Winchester 2000). The attempt to increase the numbers of milch buffaloes in India foundered on this very principle, which was ignored by the vested interests promoting the Operation Flood project. As the numbers of buffaloes increased, calf mortality increased, milk yield decreased, calving interval increased, adult mortality increased. Veterinary opinion was that all these problems were the direct result of malnourishment of the breeding females, caused by over-stocking (Alvares 1985, 149-152). It is therefore clear that any attempt to increase stocking density without a concomitant increase in fodder and veterinary resources is self-limiting, though the attempt will produce poor quality cow beef and veal carcases from under-fed animals. Increasing the population density increases the risks of endemic and epidemic disease. Population crashes of cattle in the modern third world, whether from disease or starvation, follow a roughly 30 year cycle of boom and bust (Dahl and Hjort 1976, 114-129). Part of the mistery of husbandry is in understanding such basic principles and managing the herd to obviate the boom and bust cycle.

This balance of the annual cycle of body condition and population density of the herd is the inescapable logic driving the on-going mass cull of livestock in the autumn. The herd needs to be maintained at a level population density to avoid the

deleterious side effects of increasing population size on static resources of grazing and fodder. Calf slaughter is one approach to reducing increase in the herd. Culling underperforming animals when in prime body condition after a summer on grass is another.

A further constraint on the number of cows maintained would have been the number of people available to milk the cows and process the milk, a point blithely ignored in such sweeping statements as "a situation where large herds of dairy cows were maintained to adulthood" (Sykes 2006, 59). One person can only hand milk between 10 and 12 cows, as seen for Miss Roberts and the Vycanny herd in Chapter 4. The number of people to be fed may be unknowable but it is not generally considered that there would have been no need to keep more cows than those necessary to supply the number of people, if there was no commercial outlet for any surplus. Allowing the calves to suckle their dams would obviate the need for milking but would require a slaughter strategy to contain the annual increase in the herd if the calves were reared this way.

Housing cattle may add to the comfort of man and beast but increases the human workload in building the byre, acquiring conserved fodder and bedding, daily feeding and bedding routines, then mucking out, leading and spreading the manure. Where arable land is in need of fertiliser, then the production of farm yard manure from housed cattle is economic. However in unsettled pastoral upland areas, such as the Anglo-Scottish borders, housing cattle was one way of endeavouring to keep stock safe from reivers (MacDonald Fraser 1974, 159). Outwintered cows did die from exposure in adverse weather, as seen from the example of Barnard Castle in Chapter 2, but this must have been an acceptable hazard and loss in comparison to the costs entailed in winter housing.

The tooth wear evidence for longevity, discussed in Chapter 4 and below, shows that archaeological cattle were wintered successfully year after year after year, unlike the modern Holstein-Friesian which has a six lactation life expectancy, despite state of the art housing, diet and veterinary attention. The linear classification computer scoring system developed for Holstein-Friesians had to be modified from six to sixteen lactations for application to Dexter cows (Mark Bowles pers. comm. 2012). Such longevity of individual breeding cows would restrict the number of followers that needed to be reared as replacements and result in the classic cull

patterns of very young and very old animals (Sykes 2006, 59), producing veal and cull cow beef.

5.3 The Dexter Suckler Cow Reference Skeletons

In contrast to the Dexter cow skeletons discussed in Chapter 4, which were obtained from one herd where they were born, lived and milked, the Dexter suckler cows in this section were obtained from a variety of herds. Even where one herd, Butterbox, supplied three cow skeletons (Meadow Pipit, Chevette and Clover), the cow bred in that herd, Butterbox Almond, was acquired from the Brandex herd. The foundation cows of the Zanfara herd (Abby, Chalena and Cassie) are present but no home bred females. The Woodmagic herd is represented by one cow with this prefix, Meadow Pipit, and three others mostly of this breeding: Abby, Clover and Glenalmond. The Woodmagic herd (Rutherford 2005) was a contemporary of the Vycanny herd but a much larger enterprise, with the cows also being milked in the post-war era. The breeding strategy was quite different with the deliberate elimination of all chondrodysplasia carriers but an active policy of breeding for equivalent small size without dwarfism. The Woodmagic herd has had a profound influence on the whole breed. Only the Vycanny cows Glenteitney, Kirstie and Keepsake in Chapter 4 had no Woodmagic lines in their five generation pedigrees, but all had some Jersey ancestry. Chevette was the only animal collected for this project to have neither Woodmagic nor grading up lines from another breed in her pedigree. The influence of the Woodmagic herd can be seen in this selection of suckler cow skeletons. In contrast to the Vycanny cows in Chapter 4 which were all chondrodysplasia carriers, only Cassie in this sample was a carrier.

The Bryn Y Pin herd donated the head of Betula after a request in the Dexter Bulletin for photographic examples of the "Celtic Shorthorn" horn morphology. The head had been placed outdoors in a tree between the death and decapitation of the cow in 1990 and the donation of the specimen in 1998. This was subsequently appreciated as a valuable comparandum for the interpretation of curated cattle heads on archaeological sites (Archaeological Services 2007b, 31-2) but the reason for the preservation of the head in this manner was not requested at the time and the donor is now deceased. This naturally mummified head, Plates 5: 2a-c, is unique in the

collection, so the decision was made not to prepare it as a clean skull. Limited intervention was made on the less well-preserved right side to record the tooth wear.

The barren three year old heifer, Dusty, was described in Chapter 3. The measurements of the fused bones are included in this section as, archaeologically, these would appear as adult. The eating quality of mature heifer beef also places Dusty at the cross over point between the youngstock of Chapter 3 and the beef of this chapter.

The eating quality of Dexter cow beef was sampled by the author for the four Vycanny cows in Chapter 4 and the suckler cows Abby, Meadow Pipit and Glenalmond. Abby looked well-finished on the hoof but was over-fat on the hook. The older Vycanny cows looked much plainer on the hoof but were well-finished on the hook and were very good eating. The Vycanny cows represent the best quality of "moist" old cow beef. In contrast, the suckler cows were plain cattle with no finish, apart from Abby. Abby had been left too long once she had put flesh and "finish" on. None of them were good eating by modern methods of cookery. Even so, the beef was perfectly acceptable if cooked in the medieval manner: "soakingly" or "sodden", with a thickened sauce. The suckler cows may be compared with the cow beef from casualty slaughter, perfectly acceptable if cooked long, slow and moist and then presented for consumption as, for example, pie filling, the archetypal urban fast food.

i. Life Histories of the Dexter Suckler Cows

Godstone Abby 2/3/80 – 22/2/89 = 9 years, Plate 5: 3a
Butterbox Glenalmond 3/7/80 – 27/10/91 = 11 years 3 months, Plate 5: 9
Chalena 6th of Zelston 4/10/85 – 1/6/98 = 12 years 8 months, Plate 5: 4
Woodmagic Meadow Pipit 13/10/74 – 8/2/88 = 13 years 4 months, Plate 5: 6
Crowsnest Clover 11/9/76 – 11/3/91 = 14 years 6 months, Plate 5: 8
Norscroft Cassie 14/8/81 – 8/4/97 = 15 years 8 months, Plate 5: 5a
Templeton Chevette 9/8/75 – 28/10/93 = 18 years 2 months, Plate 5: 7
Bryn Y Pin Betula (Head only) 21/2/81-1990 = 9 years

In terms of the discussion in Chapter 3 on the season of the year to retain calves for the breeding herd, it is an interesting coincidence that the two younger cows, Abby and Betula, were born in February and March while the remainder were

born July-October, replicating the historical literature for not rearing spring born calves and enhancing the potential comparability with archaeological cattle bones. The fact that all these cows lived in more than one herd and therefore experienced more than one system of management and feeding makes this group more akin to an archaeological sample, such as a Roman or medieval town, where livestock would have been sourced from a wide hinterland encompassing a range of environments and husbandry.

Abby is recorded as producing bull calves in 1982 and 1984, and may have also have calved a bull calf in 1983, when the Godstone herd only notified female births. Abby was purchased, in very poor condition and cheaply, by Bill Quay Community Farm at the national RBST sale in September 1985 as having "run with the bull". Bill Quay Farm was not unduly concerned at first when she proved not to be in calf. By 1987, she had failed to hold either to A.I. or to natural service and was offered to the author for a last chance at breeding or as a potential skeleton. Abby joined the Zanfara herd in January 1988, was served in April, together with Chalena, and appeared to commence a normal pregnancy. Once Chalena calved, Abby attempted to steal her calf, Plate 5: 3b. A month after the due date, Abby was P.D.'d not in calf and appears to have had a phantom pregnancy. Abby was beefed in February 1989 and the "calf" proved to be solid fat within the abdominal cavity.

Chalena was the foundation cow of the Zanfara herd, purchased as a six month old heifer in 1986. The first calf was born in January 1989 and Chalena then bred regularly between January and March until 1995, producing five heifers and one bull calf. The 1996 calf was born in July but required veterinary assistance due to prolonged labour. Chalena reared this bull calf but failed to hold to service until 1997, producing another bull calf, Apicius discussed in Chapter 3, in February 1998. Chalena ended as casualty slaughter as a "downer cow", having got into the barn and fallen over after getting a foot stuck in a pallet.

Cassie was bred on Stainmore and was purchased from Kirkby Stephen in August 1991, suggesting she had hitherto lived in Cumbria in an environment comparable to the Vycanny and Zanfara herds. At the time Cassie was dry, had one blind quarter and was supposedly in calf by A.I. Cyclone soon rectified that notion. Nothing is known of her breeding record prior to 1989. In the Scandal herd, Cassie calved an Angus heifer in 1989, a Dexter bull in 1990 and a heifer in 1991. In the Zanfara herd she calved between April and July from 1992-1996, producing one bull

calf, two heifers, one freemartin heifer twin to a dead bull calf (see Chapter 3) and one bulldog calf (see Chapter 3). Cassie, although housed, did not winter well over 1996-7, losing interest in feed. Cassie died quietly in her pen, pre-empting the decision to have her put down. Although suckled, Cassie was equally amenable to being hand milked or to suckling bought in Jersey calves. Cassie had the classic "dairy wedge" outline and a phenomenal amount of milk when newly calved, Plates 5: 5a-b. Though the author is an inexperienced milker, four pints were readily drawn from one quarter, without stripping out. Cassie's 1994 daughter, Clarissa, is currently the oldest cow in the Zanfara herd in 2013, and is still breeding having calved in March. This is an example of the slow rate of potential "improvement" in herds with long-lived cows, 1981-2013 covers only two generations and the second generation is still breeding.

Meadow Pipit, Chevette and Clover were foundation cows of the Butterbox herd. Meadow Pipit calved from 1977-1987, with the exception of 1981. The first three calves were born June-July, the fourth in December. After the gap year, she calved regularly in March or April. The progeny were five heifer calves, three Dexter bull calves and two Angus cross bull calves. Chevette calved annually from 1977-1993. The first four calves were born May-June, the next ten calves March-April, the 15th in February, the 16th in April and the 17th in September. The progeny were six heifers, one still born heifer, nine bulls and one still born bull. Chevette had been retained to such an advanced age because of her rare bloodlines. One bull calf was part of a DCS breeding programme to diversify the bulls available on AI. Chevette had originally had a very good udder but advanced age and multi-suckling (Garratt 1988) had caused the ligaments to stretch so her udder had descended, making it difficult for calves to suckle and increasing the risk of her standing on her teats when rising. Hence she was beefed a month after her last calf was born. Clover calved from 1979-1990, with gap years in 1981 and 1989. The calving dates show a range from March to November, with two April born and two May born calves. The progeny were two heifers, a still born heifer, an Angus cross heifer and six bull calves.

Glenalmond calved in 1982 and 1983 in the Butterbox herd, producing an April heifer and a March bull. Glenalmond was then purchased by the Dunningram herd, who only notified births of heifers in the DCS Herd Books. In this herd, Glenalmond produced April and May born heifers in 1984, 1988 and 1990. Presumably bull calves were born in 1985-7 and 1989. Glenalmond was then purchased by the Brandex herd, where a heifer was born in July 1991. Glenalmond

was offered to this project because of supposed difficulties breathing and was beefed in October 1991. The butcher found nothing obviously wrong with her lungs. The Brandex herd was then recently established and the owners inexperienced, so appear to have over-reacted to something like husk, easily remedied by dosing with wormer.

Six further cows have been culled from the Zanfara herd or died on farm but no skeletal material could be retained. Details of these cows and their breeding records are presented in Appendix 5: 1 for comparison with the cows in the reference collection. The age profile of these cull cows is contrasted with the reference cows in Figure 5: 1. It can be seen that five of the six culls were aged 8-10 years in contrast to only two of the eight reference cows. Two cows were culled for infertility, two for lameness and two were accidental deaths. This example corroborates the suggestion above that the younger, supposed "prime age", beasts supplied to the Anglo-Saxon *wics* could in fact represent poor quality meat from casualty culls.

ii. Skeletal Ageing

The epiphyses on the seven complete cow skeletons are all fused and all eight examples have the permanent dentition present and in full attrition. It can be seen from Table 5: 1 that while the age at death ranges from 9 to 18 years, the MWS scores span 43-50. There are discrepancies between calendar age and MWS, with younger animals exhibiting more advanced wear than older animals. Such anomalies can be used to cast doubt on the validity of MWS as a tool for interpreting culling decisions. For archaeological analysis, the overall pattern of MWS is of greater interest than the individual record. Jones and Sadler (2012) recorded the MWS scores for cattle of known age and feeding regime in the Julius Kühn Museum, Halle. The cattle aged from four years in this collection include only three bulls and no castrates. This group is therefore comparable in sex composition to the two Dexter bulls and total of eleven cows. Figure 5: 2 shows the calendar age at death of the Halle cattle and the Dexters. Twenty-one of the Halle examples were aged 4-7 years but no Dexters were collected in this age range. Both groups overlap at 8-9 years old but the majority of the Dexters span 11-16 years where there is only a tail in the Halle distribution. Both groups have one exceptionally old cow aged 18 years. A very different pattern can be seen in Figure 5: 3, though one that is familiar from archaeological samples. The scale on the X-axis commences at MWS 30 to demonstrate that the minimum MWS for the four year old Halle cattle is MWS 38. By way of comparison Dusty, the three year old

heifer, is at MWS 34. One of the caveats levelled at MWS histograms is the impression that all wear stages last an equal amount of time, when the individual TWS can vary from transient to persistent (Dobney *et al* 2007, 125-7). The use of known age comparative material can allow for this problem by subdividing the MWS into relevant age spans. Already, this example shows that more than half the range of MWS could comprise animals younger than four years, while MWS 38-53 covers known ages from four to eighteen. Unsurprisingly, there is no clear correlation between age and tooth wear. Figure 5: 2 shows a peak of younger animals and a tail of older ones for the Halle cattle, whereas Figure 5: 3 shows a normal bell curve distribution of MWS. There is a tantalising suggestion that the eight and nine year old Dexters match MWS 43 and 44 but no such close correlation is apparent for the Halle examples. MWS 45 indicates Dexters over 10 years old but the peak of Halle cattle at MWS 46 has to include much younger animals than the Vycanny cows discussed in Chapter 4. It is also salutary to observe that the 18 year old Dexter cow does not correspond to MWS 52.

Although there are such discrepancies at the individual level, the Dexter MWS give a more reliable *interpretation* of the range and distribution of calendar ages than the Halle cattle. The four examples at MWS 43-44 correspond to the four 8-9 year old Dexters and the nine examples in the range MWS 45-9 are equivalent to the nine 11-16 year old Dexters with the outlier at MWS 52 indicating the advanced age of the single 18 year old. This *interpretation* of the MWS, such as would be made for an archaeological sample, matches the calendar age ranges of the cattle in the overall group, even though there are striking mismatches between MWS and calendar age of individual animals. For example, the jaw at MWS 52 is not from Chevette, the 18 year old cow but from Juglans Nigra, the 13 year old bull.

The rate of tooth wear appears to have been faster in relation to calendar age for the stall-fed German Halle cattle of many breeds compared to the Dexters, with close degrees of relationship and mostly kept on poor going in a challenging environment in North-East England. In this respect, the Dexter data may be of more value for the *interpretation* of MWS data from northern England, provided that large enough samples are available to balance out the inevitable discrepancies at individual level. Where MWS can be of particular value is in identifying a cull cohort related to tooth wear and, by implication, body condition, rather than calendar age. In this respect, it is of interest that all the Dexter cows collected still had plenty of potential

wear left in their teeth, whereas the demise of the senior bull, Juglans Nigra, appears to have been partly related to the advanced and uneven wear on the tooth arcades. Sten (2004, 96) reports an ox culled at 19 years old as unable to cud through tooth loss. Chapter 2 considered dental problems in relation to mortality of Chillingham males. Differential rates of tooth wear between males and females are not normally considered for archaeological assemblages but could be a manifestation of the Ungulate Paradox considered in Chapter 2.

As noted above, Starling, the 35 year old cow that had a portrait painted (Hall & Clutton-Brock 1989, 84), was roughly twice the age of the oldest Dexter cows collected for this project. Such unusual longevity has interesting implications for the extreme MWS of 50-53 encountered in archaeological assemblages.

Jones & Sadler (2012) are refining the age estimations of older cattle, particularly where the small pillar which sits between the first two elements of the lower third molar is congenitally absent. In the present sample, the 14 year old and 18 year old cows, Clover and Chevette, exhibit absence of this pillar. Chevette also has no pillar on Molar 2, hence the low MWS for her calendar age.

Meadow Pipit, like Glenteitney and Keepsake in Chapter 4, exhibits congenital absence of mandibular Premolar 2. Dobney *et al* (2007, 181-2) discuss the frequency of this trait in a suite of Anglo-Saxon assemblages and note geographical variation in prevalence. As noted in Chapter 4, this may in part reflect the degree of relationship between the cattle supplied to the various sites. The small sample of Vycanny cows suggest this trait was prevalent within that herd whereas the cows in this chapter were sourced from a range of herds, although most were related to the Woodmagic herd, which bred Meadow Pipit. Another mandibular non-metrical trait discussed by Dobney *et al* (2007, 181-2), which is also seen among the Dexters, is variation in the conformation of the mental foramen, with the example of Chalena . However, more commonly seen by the author in archaeological assemblages is absence of the hypoconulid on mandibular molar 3. This trait was not observed among the Dexters. Given the examples of the absence of premolar 2 in the Dexters, this was unexpected. Whether this merely reflects the small size of this Dexter reference collection, or perhaps genetic drift in the population, is unclear.

iii. Osteology, Pathology and the Suckler Cow

iv. Skull and Mandibles

The cause of Abby's poor condition when purchased by Bill Quay became apparent when cleaning the skull and mandibles. The right mandible appears to have sustained traumatic injury, subsequently healing with massive thickening of the horizontal ramus in the region of molars 2 and 3, Plates 5: 10a-c. Both these teeth appear to have been lost at the time of injury. In consequence, there is malocclusion and abnormal wear on the right maxillary and mandibular teeth. Premolars 3 and 4 and molar 1 have pronounced ridges and grooves while maxillary molars 2 and 3 are abnormally long in comparison. In contrast, on the left side both upper and lower teeth exhibit very flat wear, with the exception of maxillary molar 3 which has developed a "hook", as described in Chapter 2. In life, it was noticeable that Abby had a very ponderous cudding motion, favouring one side. Cudding must have been extremely painful when the break in the mandible was fresh, hence the poor condition of the cow at purchase. Once the break had healed, the cow recovered condition and there was no outward sign of the massive trauma previously endured. Nevertheless, the subsequent lack of breeding success suggests the long term impact of this injury on the animal. The necessity to cud on only one side may well have enhanced the MWS for the age of the animal, but such considerations are unknowable for an archaeological specimen. Pitting round the alveoli of all four tooth rows indicates ongoing gum inflammation, or periodontal disease, at the time of death. Further pitting is present on the articular surface of the left mandibular hinge, suggesting that the extra stress from one-sided cudding was beginning to impact on the joint surface. The medial aspect of the right mandibular hinge shows either a massive OC lesion in the joint surface or the healing of a break or fracture in the bone at the time the ramus was broken. The latter could be more probable as a result of the impact shock wave travelling up the vertical ramus as, discussed below, other OC lesions are absent from this skeleton. The muscle attachments for the left hand mandible on the zygomatic arch and temporal are far more pronounced than on the right hand side, again suggestive of the impact of one-sided cudding.

Pitting indicative of gum inflammation or periodontal disease round the alveolar margins of all tooth rows was observed for the remaining six cows. In Glenalmond this was more pronounced on the lingual borders. Clover shows more

pronounced pitting round the maxillary teeth alveoli, with bone resorption round the roots of the left hand maxillary molar 1. While the tooth is present, it would have been lost *ante mortem* if the cow had not been culled. This problem extended to the occluding mandible, where the anterior cusp of molar 1 has broken in life and been lost from the jaw. There is bone resorption round the empty socket, which has rounded edges of lamellar bone but had not healed over. Cassie's maxillae exhibit pitting around the alveoli of the tooth rows and advanced resorption of bone, exposing the teeth roots, on the buccal margins. Similar changes are apparent on the mandibles, with particularly severe resorption round the alveoli of the left premolars 2 and 3. The swelling of the bone and the margins are modelled in smooth lamellar bone, indicating that the infection or inflammation had healed in life. Chevette has pitting on the maxillae round the lingual alveolar borders and bone resorption, exposing the roots of the teeth, on the buccal borders. Similar pitting is present on the mandibles, though again more pronounced on the buccal borders. Dental calculus on the tooth crowns is present on all cows and may be linked to the prevalence of gum inflammation.

Glenalmond, Chalena, Pipit, Clover and Chevette had been dehorned so there are scurs and osteomyelitis (Baker & Brothwell 1980, 74) on the sites of the horn cores. Merging into the osteomyelitis is the age-related roughening of the frontals and orbits, described in Chapter 2. This is most pronounced in Chevette, the oldest cow, but surprisingly slight in Cassie, who was older than the remaining cows but retained her horns.

There are exostoses forming on the medial borders of both Glenalmond's mandibular hinges, while Clover has pitting on the articular surfaces of both mandibular hinges, in addition to medial exostoses. As noted above, Chalena's left mandible has a double mental foramen. The secondary foramen is vestigial on the right mandible.

Cassie displays perforations in the occipital, Plate 5: 11, and Chevette has a small perforation above the left occipital process, Plate 5: 12. This is a non-metrical trait that has generated much debate, commencing with Brothwell (*et al*. 1996) and summarised by Fabiš and Thomas (2011), with the current consensus being that this is a congenital hereditary trait probably carried by a recessive gene.

Chevette's right occipital condyle has eburnation and pitting.

Meadow Pipit, Clover and Glenalmond show most similarity in the suite of changes described above, which may reflect their degree of kinship, husbandry while in the Butterbox herd and age at death.

v. Ribs and Vertebrae

The age-related rugosity of the bone surfaces and ossification of soft tissue attachments, seen for the dairy cows in Chapter 4, was generally present on the ribs and vertebrae of these suckler cows. However, Meadow Pipit and Chevette, the oldest cow in the collection, showed the least development.

Unlike the other cows, Clover was professionally butchered so the vertebrae have been split sagitally and the ribs cut into sections. The bones donated to this project were from slaughter and cutting, not consumption. Sections of the thoracic and lumbar vertebrae are absent, indicating that rib roasts and sirloin on the bone were retained.

Notches and foramina for blood vessels were observed on the caudal borders of ribs from all seven cows, further confirming that this is a normal trait. Abby has one rib showing a healed fracture in the distal shaft. Despite a lung problem being cited as the reason for beefing Glenalmond, no sign of any active woven bone, indicative of a reaction to infection, is present on the medial side of any of Glenalmond's ribs. The vulnerability of a dehorned cow in a herd also running horned cows, as was the case with Dunningram, is demonstrated by three left side and two right side ribs exhibiting healed fractures, Plates 5: 13a-b. Glenalmond would appear to have been low in the cow hierarchy as the degree of lamellar bone formation suggests a sequence of injuries rather than one traumatic event. Cassie has a long healed fracture on one rib. The distal shaft is out of alignment, otherwise this injury would not have been obvious from the smooth lamellar bone surface.

Abby has examples of "beaking" exostoses on the centra of thoracic and lumbar vertebrae and the terminal thoracic vertebra has exostoses on the cranial facets of the neural arch. While not fully bifid, seven of Glenalmond's thoracic vertebrae show broadening and separation of the spines as though the bifid factor is incompletely expressed. One right hand pair of facets on the neural arch of one thoracic vertebra show exostoses and eburnation. Chalena exhibits more advanced degeneration of this type, commencing at VC7, running along the thoracics, particularly VT 8-14 and into the lumbars. VT 8-10 also have exostoses round the

articular facets for the ribs. The neural arch facets at the junction of VL 4-5 move freely but cannot be disarticulated. Meadow Pipit has pitting on the caudal epiphysis of VC02 but no other degenerative changes. Instead Pipit displays some congenital anomalies with large foramina on the left side of the centrum on VT 10-11 and smaller foramina on VT 12-13, Plate 5: 14. Similar foramina are present on three of Clover's right hand thoracic centra, though not as pronounced as the examples seen in Meadow Pipit. Chevette has a single large foramen, on the right centrum of VL 6. Degenerative changes on Clover's vertebrae include one cranial centrum with pitting in the articular surface, neural arch facets with lipping on VL1-5 and with pitting of the surface on VL2-3. The sacrum has lipping on the lateral border of the centrum and pitting of the surface. Like Clover, Cassie also has the foramina on the right side of the centrum on three VT and the left centrum on VL 5-6, Plates 5: 15a-c. In Cassie there is an interesting association of this anomaly with the perforations in the occipital, suggesting that both are possibly related congenital non-metrical traits in the axial plane. Asymmetry in the vertebrae of females may be expressed in these one-sided foramina, rather than the shift in the sagittal plane seen for the male vertebrae in Chapters 2 and 3. Cassie has a range of arthropathies on the thoracic vertebrae including pitting on the cranial articular surfaces of the centra, lipping round the articular facets for ribs and areas of woven bone growth on centra indicating inflammation active at the time of death. The articulation of VL6 with the sacrum exhibits gross pathology, Plates 5: 15c-e, comparable with that observed for the Vycanny cows in Chapter 4. The centra show expansion of the margins, particularly on the left hand side. The joint surfaces are pitted and there are large patches of eburnation on the lateral borders of the centra. There is massive expansion of the neural arch facets, with eburnation and grooving of the articular surfaces. Unfortunately VL6 had to be broken at this point to separate the pelvic girdle from the vertebral column and the right hand neural articulation has been lost. There is an area of woven bone on the right side of the centrum.

Chevette displays pitting and eburnation on right cranial facet of the atlas, matching that observed on the occipital condyle. The entire length of the spine cervical, thoracic and lumbar vertebrae have lipping on the neural arch facets, also the rib articular facets of the thoracic vertebrae. In the lumbars, VL 4-5 have movement but cannot be dislocated, while VL 3-4 have been separated but will not re-articulate.

Examples of pitting and eburnation were seen on individual joints throughout the spine.

vi. Forelimb

The proximal cartilage of the scapula has not yet ossified in Abby, but this process is complete in the remaining cows. Abby has the muscle attachments of the humeri and radii developing the rugosity previously seen for the older cows in Chapter 4. This rugosity extends to the proximal medial and lateral borders of the metacarpals. There are no OC lesions on the joint surfaces of Abby's forelimb bones, though both glenoid fossae on Glenalmond's scapulae exhibit minor lesions. Rugosity is developing as described for Abby. In addition the medial borders of the ulnae semi-lunaris show the expansion described in Chapter 2 and the proximal medial articular surfaces of the metacarpals have OC depressions, mirrored in the articulating carpals.

Chalena has particularly broad and robust scapulae in comparison with the other cows, Plates 5: 16a-b. While the scapula was not selected for measurement and analysis in this study, it would appear that there is scope for further work on this element. The distal humeri of Chalena both show broad anomalies in the articular surfaces, though of differing pattern and extent, which are mirrored in the proximal radii and ulnae. Both metacarpals show OC lesions on the proximal medial articular surfaces and corresponding carpals, also present on the distal surfaces of both pairs of radial and intermediate carpals. All of Chalena's limb bones are visually robust, with the rugosity and minor lipping round the edges of joint surfaces seen for the bulls in Chapter 2.

Meadow Pipit was the first cow skeleton to be prepared and so was originally taken to be the Dexter norm. The bones are gracile and appear superficially similar to the generality of archaeological finds. Given the age of Meadow Pipit, there is a striking absence throughout the skeleton of the pronounced rugosity caused by ossification of soft tissue attachments, which otherwise appears to be a normal feature of the adult Dexters. The reason for this is currently obscure. Genealogy appears unlikely as Meadow Pipit shares common ancestors with the other cows. Body condition also appears unlikely. Meadow Pipit was very thin when beefed but so was Glenalmond and the other cows had gone through cycles of poor condition, particularly Abby.

Clover appears similar to Pipit, being more gracile and with less of the rugose bone surface development, though this is present on the ribs and vertebrae. Clover has matching OC lesions on both metacarpals and carpals 2+3, with further examples on both carpals 4.

Cassie appears more comparable to Chalena with very "chunky" bones. Both Cassie and Chalena have Ypsitty bloodlines, absent from the Woodmagic breeding of Meadow Pipit and Clover. "Chunky" was a cow family name in the Ypsitty herd, suggesting that more robust build was preferred. Cassie has an OC lesion in the glenoid fossa of the left scapula. Both ulnae show pronounced expansion of the margin of the semi-lunar facet. Such expansion is present in the other cows but far less marked. Cassie has matching broad OC depresssions on the distal medial facets of the radii and radial carpals, with small OC lesions on the intermediate carpals and matching lesions on both carpals 2+3 and proximal metacarpals. The right proximal posterior metacarpal also has clear striation of the triangular facet (Bartosiewicz *et al* 1997, 45 Fig 29). Both metacarpals have exostoses on the distal shaft, which is more pronounced on the left leg together with broadening of the lateral condyle.

Chevette has exostoses on the medial borders of the glenoid fossae of both scapulae, though more extensive on the left side. The articulating surfaces of the right intermediate carpal and carpal 4 display eburnation. Both carpals 2+3 and proximal metacarpals have matching OC lesions. There are minor exostoses on the distal anterior shafts of the metacarpals, together with broadening of the medial condyles.

vii. Hindlimb

The acetabula of Abby display the clear bridge of the ilial and pubic margins producing a foramen, described in Chapter 2 for the Chillingham bull. The hindlimb bones of Abby are also developing the rugosity previously alluded to, including on the medial *sulcus tendini* of the calcanea. This is common to all the cows. Glenalmond's acetabula are notched, the limb bones are rugose and there are the broad OC lesions on the astragalus, centroquartal and proximal metatarsal observed in Chapter 4 on the Vycanny cows. It should be noted that Glenalmond was a grand-daughter of Glenteitney (see Chapter 4), which is a tantalising hint that heredity as well as environment may contribute to the aetiology of the condition. Glenalmond was not a chondrodysplasia carrier, so an early hypothesis suggesting a link between OC lesions and dwarfism was shown to be incorrect. Chalena shows substantial bridging of the

ilial-pubic border of the acetabulum, with a small crease-like foramen. The anterior aspect of the left femoral head has an area of eburnation but there is no corresponding eburnation on the acetabulum. The astragali have broad OC lesions. The tarsal 2+3 has fused to the left centroquartal, with exostoses on the anterior border and pitting on the distal surface, with matching pitting and exostoses on the proximal metatarsal. On the right side, this tarsal has not yet fused to the centroquartal but there are exostoses round the anterior borders of both and pitting of the articulating surfaces. This onset of spavin and degeneration of the hip joint were seen in life as a slight lameness in the affected leg. This was by no means a severe limp and Clarissa has survived eight years since the onset of a similar rolling gait without apparent discomfort. Chalena did not exhibit the debilitating lameness which has necessitated the culling of other cows.

Meadow Pipit has substantial bridging of the ilial-pubic margin, with a very small foramen. There is a small patch of eburnation on the left acetabular pubic facet. There is a more pronounced area of eburnation on the articulating femoral head and a corresponding smaller patch of eburnation on the right femoral head.

The right acetabulum of Clover has extensive exostoses round all margins and a broad area of eburnation and pitting of the joint surface on the ilial facet, Plate 5: 17a. The articulating femoral head has similar exostoses surrounding the head, with a broad area of eburnation and extensive pitting of the joint surface both inside and outside the area of eburnation, Plates 5: 17b-c. The owner's description of Clover's last winter is very helpful for understanding archaeological finds of comparable pathology:

"Clover was always an extremely active cow – even when she was beginning to get elderly. However last autumn - about October – I first noticed she seemed to be limping a bit. It got worse quite rapidly over the winter and by the time she went (11/3/91) it was really pretty bad. Of course she was in the yard all winter and so her exercise was restricted which may have hastened the process. She got about reasonably alright on the level surface of the yard but had quite a bit of difficulty getting up the slope of manure to get into the shed. However she did keep moving about reasonably in spite of the discomfort. She tended to drag the leg a bit if she could. I was surprised how quickly she got bad" (Mrs P. Garratt pers. comm. 1/4/91).

Clover's left hand acetabulum shows the bridge and foramen on the ilial-pubic border. There is a small patch of eburnation on the ilial facet of the acetabulum and a matching patch on the femoral head. The tarsals 2+ 3 are fused to the centroquartals

on both sides but there is no associated degeneration of the articular surfaces. Both metatarsals display a pronounced ridge on the proximal medial shaft, of a type more commonly encountered in sheep (Brothwell *et al* 2005). A similar ridge is present on the metatarsals of Kirstie and Glenfinlet (Chapter 4), with advanced spavin. The ridging on Clover's metatarsals and fusion of the two tarsals suggest a mild form of spavin. Both the ridges and ankylosis appear to be long-established, with no active woven bone at the time of death.

Cassie has massive bridging of the ilial-pubic margin with the foramen reduced to a small crease interiorly. The ischial facets of both acetabula have worn through to expose the underlying cancellous bone, with eburnation on the right side. The left femur has lipping round the head and the distal end. The proximal surface articulating with the ischium has worn through to expose the underlying cancellous bone and there is eburnation on the distal medial condyle. The proximal right femur also has exposure of cancellous bone, bordered medially with eburnation together with eburnation and pitting on the anterior femoral head. There is lipping round the proximal and distal joint surfaces but this is not as pronounced as on the left side. The intercondylar eminence of the left tibia has been literally ground away, with eburnation. The patellae have lipping on the distal margins.

The joint surfaces of both lateral malleoli have either pitting or exposure of cancellous bone. Both centroquartals have ankylosis of the tarsal 2+3, with lipping on the anterior border. There is pitting and eburnation on the distal lateral facet of the right side too. Both metatarsals display matching expansion of the proximal anterior borders with pitting and eburnation on the articular facets, which is more pronounced on the right.

Chevette has bridging of the ilial-pubic margin with a tiny foramen. This process was active at death with large area of woven bone on the left and small patches on the right. The remodelling of ilial-ischial borders is largely lamellar bone but there are patches of woven bone on the right. The ischial notches display a large area of woven bone on the left and a small patch on the right.

There are exostoses on the medial and posterior borders of the right femoral head, which are also present though less advanced on the left side. There are small OC lesions on both femora posterior to the distal trochlea. The right tibia has lipping on the distal posterior border. The calcanea have a ridge of lamellar bone on the anterior of the calcaneal tuber, with woven bone in addition on the right. Both have

lipping and eburnation on the processus anterior. The right astragalus has lipping, a large OC lesion in the distal joint surface and eburnation on the facet articulating with the calcaneum. Similar changes are present but less severe on the left astragalus. Both centroquartals have ankylosis of tarsal 2+3 with lipping, and lesions in the joint surfaces matching those observed on the astragali.

Both metatarsals have a pronounced ridge on the proximal medial shaft, with expansion and lipping of the proximal end, more pronounced on the left. The distal shafts have lateral anterior and posterior exostoses.

viii. Phalanges

Neither Abby's nor Glenalmond's phalanges exhibit OC lesions, and display proximal exostoses only on the third phalanges. The absence of such lesions on Glenalmond's phalanges but the presence of the broad articular surface depressions on her astragali suggests the two conditions may not necessarily be related. Chalena also has proximal exostoses on the third phalanges. In addition there are OC lesions on the articular surfaces of four third phalanges. The first phalanges have lipping of the distal medial shaft, comparable with that seen for the stage 3 example of Bartosiewicz *et al* (1997, 49), but without the other outgrowths. On the third phalanges, Meadow Pipit has pronounced proximal exostoses on two, small exostoses on four and minimal exostoses on two. Clover has proximal exostoses on all third phalanges but no OC. Cassie has lipping on all proximal first phalanges with pronounced expansion on five. There is one proximal and one distal example of OC. The second phalanges have five examples of proximal lipping and five examples of distal OC. Six of the third phalanges have the transverse OC lesion, two have clear proximal exostoses but the remainder are not well developed.

Chevette has proximal lipping and exostoses on all first and second phalanges ranging from severe on two, moderate on three and slight on three. All the third phalanges have proximal exostoses but these are not as well developed as those present on other cows. Five have a pit or lesion on the medial border, seen in Chapter 3 for the young stock where such lesions are healing over, but not the normal transverse line of OC.

ix. Measurements

The measurements of the distal trochlea of the humerus are presented in Figure 5: 4a for the individual cows and in Figure 5: 4b in comparison with the Vycanny cows and the bulls. It can be seen that Chevette, who had minimal relationship to the other cows, falls at the smaller end of the scale whereas Cassie, a known chondrodysplasia carrier, is considerably larger than the other suckler cows. The central cluster of Abby, Glenalmond, Meadow Pipit and Clover could reflect the relationship of Woodmagic breeding. Figure 5: 4b shows that Chevette falls between the clusters of Vycanny and Woodmagic bred cows. Cassie remains an outlier from the cows but not within the bull range, though if this were an archaeological sample Cassie would be interpreted as falling in the male range. The distal tibiae in Figure 5: 5a show that Cassie is still the outlier at the larger end of the scale but Chevette is now within the main group and Meadow Pipit is at the bottom end of the range. Comparison with the Vycanny cows and the bulls in Figure 5: 5b show an overlap between the Vycanny cows and the suckler cows, with Cassie midway between the bulls and other cows. Since the distal tibia and astragalus articulate, it might be assumed that the proportions of the two will generate broadly similar data. However Figure 5: 5a for the tibia and Figure 5: 6a for the astragalus show small differences, with Chalena at the larger end of the scale but Cassie and Glenalmond at the bottom of the scale, rather than Meadow Pipit. Figure 5: 6b shows that one of the Vycanny cows and one of the bulls, both chondrodysplasia carriers, fall within the suckler cow range. Figure 5: 6c compares all the cows against the adult bulls and the young, beefed, males. While the extremes of the range can be clearly ascribed to male or female and the young males are generally larger than the cows, there is sufficient overlap between the two to obscure a clear line of separation in the mid-range, were this an archaeological sample.

Tables 5: 2a-d show the withers heights estimated from a selection of four major limb bones. While complete measurable humeri, femora and tibiae are rarely encountered archaeologically, outside burials of complete carcases, the data from these Dexter cows indicates the variation in the length of other limb bones where the metacarpals are the same length. Clover and Cassie, for example, have a difference of 16mm in femoral length, while Abby and Chevette have a difference of 10mm in tibia length. Meadow Pipit was the first of the Dexters of known withers height to be tested by the range of factors for metapodials presented by Driesch and Boessneck (1974,

336). Only the average of either Zalkin or Fock's factors for cows and steers gave the correct result, justifying the subsequent use of this average factor for archaeological finds. The data in Tables 5: 2a-d confirm that the estimated heights from the metacarpals using this average factor give the most reliable indication of the known heights of the Dexters.

Figure 5: 7 compares the range of withers heights for the dwarf and normal Jersey cows, discussed in Chapter 4, with the short-leg Vycanny cows and the non-short Dexter suckler cows. The boundary between the short and non-short Dexters appears clear cut but in fact the two cows falling at 1.02m in height comprise one chondrodysplasia carrier and one non-carrier. The individual breeds show a clear disparity in height between the dwarf and normal height cows but the dwarf Jersey range and the normal Dexter range overlap. This has interesting implications for the interpretation of such graphs based on archaeological finds from sites supplied from a large hinterland with a variety of livestock types. Merely reconstructing the range of withers heights does not necessarily give an indication of the proportion of dwarf carrier cows in the sample. The tripartite division could easily be construed as females, castrates and entire males. The normal Jerseys could be interpreted as the introduction of improved, in the sense of size, cattle. It is unlikely that such a graph would provoke discussion of archaeological finds in terms of two populations of females manifesting dwarfism.

x. Discussion

Of the suckler cows, the gracile bones of Chevette and Meadow Pipit would not appear out of place in an archaeological assemblage. This is of interest in suggesting that some non-short Dexters may preserve the build of the ancestral Kerry before the breeding of the short-leg Dexter caused the separation into two distinct breeds. The modern Kerry, though of gracile build, is rather taller than most non-short Dexter cows. The cows with the most robust bones, Chalena and Cassie, both descend from the Ypsitty herd. This breeding does not appear in the pedigrees of Chevette and Meadow Pipit. The Ypsitty herd was based in Cumbria while the Woodmagic and Templeton herds, where Meadow Pipit and Chevette were bred, were based in Devon. It might therefore be tentatively suggested that the gracile Meadow Pipit and Chevette contrasting with the robust Chalena and Cassie manifest in their skeletons different bloodlines within the breed, ultimately reflecting the breeding policies of long-

established herds in differing environments. What the suckler cows demonstrate is the variation still present in a breed that passed through a genetic bottleneck only 50 years ago. Such variation highlights the inherent problems in trying to reconstruct "breeds" and "improvement" from archaeological samples.

The total sample of Dexter cows provides an opportunity to examine the occurrence of a suite of non-metrical traits that are regularly encountered in archaeological assemblages of cattle bones. For example, late 4th century Lincoln produced seven examples of occipital perforations among 92 horn cores in a collection of 1109 cattle bones (Brothwell *et al* 1996, 484). The assemblage from Lincoln also had a high proportion of other congenital non-metrical traits, such as absence of mandibular premolar 2 and the hypoconulid on molar 3, leading to the suggestion that a restricted breeding pool of cattle had resulted in the expression of recessive characters (Brothwell *et al* 1996, 480-1). In comparison, the Dexter cows include one clear example and one minor example of occipital perforations out of eleven clean skulls. Only one cow displayed an atypical mental foramen, whereas three cows exhibit congenital absence of mandibular premolar 2. None of the Dexter cows have absence of the hypoconulid on mandibular molar 3. Dobney (*et al* 2007, 181-3) discuss the frequencies of these traits in a range of archaeological assemblages, which demonstrate considerable variation between sites. Of particular interest in this very small sample of Dexter cows is the absence of only one of these non-metrical traits, when prevalence in archaeological finds generally falls below 5%. This suggests a broader similarity between the Dexters and archaeological cattle than the mere overlap in metrical distributions discussed above. Dobney (*et al* 1996, 34) queries the received wisdom that restricted gene pools act as a mechanism allowing expression of these traits as recessive characters. Given the genetic bottleneck that the Dexter breed encountered in the later 20th century and the high levels of inbreeding within individual herds, the expression of recessive traits might be anticipated. The present sample of Dexters is too small for confident association of particular traits with individual herds or family lines of cows but there are tantalising hints of such possibilities.

No example of gross asymmetry of the vertebral column was observed for any of the Dexter cows, unlike the males discussed in Chapters 2 and 3. This may suggest possible sex-linkage of such anomalies to males. However, the unilateral foramina in the vertebral centra seen in the Dexter cows could represent the female equivalent of

such asymmetry. Furthermore, occipital perforations and abnormal mental foramina may also represent developmental defects of the axial skeleton in females, comparable to those described in Chapter 3 for the males. Such associations are not normally sought in archaeological assemblages as mandible and occipital fragments are studied in isolation from the vertebral column, which is ignored by most standard recording methodologies.

In the suckler cows, age-related degeneration of the vertebral column is more common on the dorsal plane, indicated by the exostoses seen round articular facets. Only one of the suckler cows displays the massive pathological changes to the VL6-sacrum articulation seen in Chapter 4 for the Vycanny cows. The suckler cow in question, Cassie, had an extremely well-developed udder, like the Vycanny cows, suggesting the possibility of an association. This degeneration of the VL6-VS1 joint may be a manifestation of spondylosis deformans, which is reported to be "rare in cows" but more common in bulls (Baker & Brothwell 1980, 129-30). This rarity in cows may be more apparent than real as the condition has been studied particularly in bulls because of the impact on the ability of the bull to serve cows. The stiff-legged, high-yielding, older cow has not attracted the same veterinary attention.

The known history of the degeneration of Clover's hip joint is a valuable contribution to the interpretation of archaeological finds of comparable pathologies. It can be seen that Groot's (2005, 54-56) contention that such pathology indicates the use of cows for traction is not tenable.

Like the older Vycanny cows, Glenteitney and Kirstie, Cassie exhibits degeneration of the stifle joint as well as the hip. While age is an obvious predisposing factor, the fact that all three cows had exceptional udders may suggest that this placed strain on the joints of the hindlimb. Cassie, who was certainly not chained in a byre over winter in her later years, displays far less advanced spavin (see Bartosiewicz *et al* 1997, 43 Fig 26) than the Vycanny cows of comparable age.

It has become apparent in the examination of the Dexter reference skeletons that there is far more variation in the morphology of the calcaneum and astragalus than is normally observed or recorded by the author in archaeological finds. There are several reasons for this. In the Dexters, anomalies were actively being sought. In archaeological bones, cataloguing is an exercise in the rapid recording of standardised information. Only gross pathology therefore gets noted. Also the condition, colouration and cleanliness of the archaeological bone surfaces can mask some of the

minor anomalies apparent in the Dexters. The general expansion of bone surfaces on the calcaneum in association with the *sulcus tendini*, seen on the Dexter cows, suggests that the stress on this joint is not traction but more probably the weight and size of the udder when in milk.

This consideration of the Dexter cows suggests that the zooarchaeological quest for the draught ox and the search for pathology diagnostic of draught may have obscured the evidence for the dairy cow. The unnatural udder of the high-yielding milking cow could be expected to put as much stress on the skeleton as draught work. As there are limited ways in which bones can respond to such stress, similar pathologies may be anticipated from differing stimuli.

5.4 Archaeological and Recent Case Studies

The conformation of cattle is rarely considered in hypotheses of either dairy exploitation or "improvement" in beef carcases. However, both estimates of withers heights and breadth of articulations can help suggest preferences for either gracile dairy build or robust beef build. The Dexter cows, as a robust dual-purpose breed, can provide a guideline for suggesting that more gracile bones might represent dairy conformation, while more robust bones might imply beef conformation and comparable bones similar dual-purpose capability.

The selection of sites for metrical comparison with the Dexter cow skeletons has been limited to those where appendices of bone measurements have been published or the author has recorded the assemblage and has access to the archive data. Within these constraints, geographically and temporally diverse sites are considered, to establish how useful the Dexters are for establishing conformation and for confirming interpretations of female: male distribution patterns, fundamental to interpretations of dairy strategies.

Case Study 1: Grimes Graves

Grimes Graves remains a type-site for the interpretation of a dairy-based cattle economy, with the slaughter population principally consisting of calves and adult females (Legge 1992). The bones were recovered from Bronze Age midden deposits.

Withers heights for the Grimes Graves cattle were not considered by Legge (1992) but have been calculated from the metacarpals, using the average of Zalkin's

factors, and plotted with the Dexter cows in Figure 5: 8a. The non-short Dexters fall comfortably within the Grimes Graves range, though it is clear that cattle comparable in height to Chalena at 1.11m were perhaps of preferred stature. The Grimes Graves cows may have been of more slender build than the Dexters. Though the distal breadth of the metacarpals in Figure 5: 8b again shows overlap between the archaeological size range and the Dexter cows, the Dexters extend the Grimes Graves cow range. Legge (1992, 38) stated that five of the distal metacarpals were certainly male and these are apparent in Figure 5: 8c in the range 61-66mm DB. The two Dexter bulls lie at the top of this range. The Dexter cow range may suggest that the Grimes Graves individual falling between the clear female and male ranges could be a large female. The astragali in Figure 5: 8c show that seven of the Dexter cows fall within the main size range of the Grimes Graves cattle. This brief overview and comparison with the Dexter cows confirms the original interpretation that the bulk of the assemblage derives from cows. While not identical, the overlap between the metrical data from the Dexters and the Bronze Age cattle does suggest sufficient similarity that the production data from the Dexters could be applied to hypotheses not considered by Legge, on the possible management and yield from the Bronze Age cattle. In particular, the eating quality of cow beef, discussed above, may help explain the absence noted by Legge (1992, 33) of young male cattle, presumed by Legge to be optimal beef carcases.

Case Study 2: Lincoln

Lincoln was one of the four late Roman provincial capitals. Excavations along the Waterfront yielded large numbers of butchered cattle bones deposited in the late 4th century (Dobney *et al* 1996, 2). Similar large concentrations of cattle bones have also been recovered from late or post Roman levels at Roman forts, such as Piercebridge (Rackham 2008, Rackham & Gidney 2008) and Binchester (Cussans & Bond 2010). However the Lincoln report (Dobney *et al* 1996) has the advantage that the metrical archive is published in its entirety on paper, allowing re-calculation of the data to incorporate comparison with the Dexter cows. The upland character of the hinterlands that may have supplied cattle to Piercebridge and Binchester might be seen as favouring dairy strategies, as discussed in Chapter 4. The lower lying land of Lincolnshire has more potential for arable cultivation and therefore the supply of cull draught oxen to Lincoln.

Withers heights for the Lincoln cattle have been calculated from the metacarpals, using the average of Zalkin's factors, and plotted with the Dexter cows in Figure 5: 9a. The factors and elements used to calculate withers heights are not stated by Dobney (*et al* 1996, 33 & 100) but there is a discrepancy, with the present estimates indicating cattle of lesser stature than the height range originally published. It can be seen that the Lincoln range in Figure 5: 9a falls into two main groups. The larger group of smaller cattle overlaps with the taller of the non-short Dexter cows, suggesting a preponderance of cows in the Lincoln sample.

The distal breadth of the metacarpals in Figure 5: 9b shows that the peak range of the Lincoln cattle overlaps more closely with the Dexter cow range. Unlike the withers heights estimated from complete bones, the distal metacarpals, which include many more examples from broken bones, include some examples that are smaller than the Dexter range. Since these are fused bones from adult cattle, the narrowest distal metacarpals hint at the intriguing possibility of miniature or dwarf cattle in the population.

The astragalus is a robust bone that survives well and a large sample was obtained from Lincoln, plotted in Figure 5: 9c against the Dexter cows. It can be seen that the bulk of the Lincoln sample and the Dexter cows fall within the range bounded by GL 65mm and DB 43mm. Like the distal metacarpals, some of the Lincoln examples fall below the smallest of the Dexter cows. However, the astragalus is not a bone that can be aged, so the smaller Lincoln examples could be junior animals rather than particularly small adult cows.

These plots demonstrate that the majority of the cattle butchered in late 4th century Lincoln were smaller animals, presumed to be cows. The metrical data indicate that the bones from some of the modern Dexter cows are of comparable dimensions to the Lincoln bones and only the short-leg Dexter cows would be readily detected as a separate population from the withers heights estimates. The original discussion of the cattle metrical data from Lincoln (Dobney *et al* 1996, 31-33) centred on elucidating chronological changes in the size of cattle supplied to Lincoln from the pre and early Roman occupation through to post-medieval deposits. No consideration was given to the sex ratio of the cull cattle through time and how this might impact on the interpretation of the size of the cattle. While it is not proven, the high proportion of smaller cattle similar in size to, but possibly more gracile than, the Dexter cows does suggest that the majority of the beef available in 4th century Lincoln might have

been cull cow beef. In turn, this suggests that pastoral dairy farming was of greater importance in the hinterland of Lincoln than arable cultivation with oxen. By way of comparison, the majority of the cattle astragali from Binchester (Cussans & Bond 2010, 498) and Piercebridge (Rackham 2008, 277) fall within the range bounded by GL 65mm BD 43mm, seen as encompassing the majority of the Lincoln examples and the Dexter cows. The, admittedly limited, data from the astragali appear to suggest a broad concordance in the size and sex ratio of the cattle supplied to these late Roman sites for beef.

Case Study 3: Flixborough

The occupation at Flixborough yielded large datasets of measurements from the cattle bones for a succession of phases from the 7th to 14th centuries. The distal tibiae, rather than the astragali, are presented as scatterplots (Dobney *et al* 2007, 157-158) and show a majority of smaller animals, presumed to be cows, throughout the phases of occupation. Comparison with Figure 5: 5b shows that the Dexter cows falling within the range bounded by DB 63mm and DD 49mm provide a useful "box" which, if transposed to the Flixborough graphs, encompasses the smaller cattle. In this instance, the Dexter size range can be used to suggest where the division lies between the male and female size distributions in the Flixborough graphs. The Flixborough tibiae include many examples smaller than the modern Dexter cows. Reconstructed withers heights are presented by Dobney (*et al* 2007, 151) but no information is given on either the factors or the intact skeletal elements used to calculate these heights. Using the average of Zalkin's factors on the minimum lengths of the metacarpals from five phases (Dobney *et al* 2007, 150) gives minimum withers heights, in chronological sequence, of 1.10m, 1.07m, 1.02m, 0.99m, 0.99m and 1.03m. These are all far smaller than the minimum heights presented by Dobney (*et al* 2007, 151) but provide a good match with the Dexter cow height range in Figure 5: 7. The presence of cows possibly less than a metre high, together with the very petite and gracile distal tibiae is noteworthy. While the Dexters have shown that height and build are not necessarily indicators of chondrodysplasia carriers, it is possible that the very smallest cows in the Flixborough range may be indicators of another form of dwarfism in this cattle population. Ancient DNA might be able to resolve this question. If these very small and gracile cows were not carriers of a form of dwarfism, it may be possible to inform Dexter breeding strategies to produce an animal of similar phenotype.

Case Study 4: Ripon Market Place

Excavations in Ripon market place (Archaeological Services 2011) produced an assemblage of cattle bones from the medieval deposits dominated by broken metapodial bones, thought to derive from hides for tanning and the production of neat's foot oil for leather dressing. The opportunity was taken to quantify the incidence of the small, roughly circular, depression in the proximal medial articulation of the metacarpal, classified as a manifestation of OC. The overall incidence in the medieval phases of refuse disposal in the market place was 25%, or 8 of the 32 of the proximal metacarpals. This depression was most prevalent in one phase, with 4 examples out of 7 bones. However, even this does not compare with the sample of 11 Dexter cows with 8, or 72%, exhibiting this depression.

The measurements of the distal metacarpals from Ripon were originally interpreted as smaller females, larger males and a possible group of castrates lying between the two extremes. Figure 5:10 plots the Ripon data against that for all the Dexter cows and the two Dexter bulls. It can be seen that there is good correspondence between the known sex Dexters and the Ripon data, indicating a bimodal distribution between males and females. The putative castrates now fall at the upper end of the Dexter female range. Whatever the differences between the live animals, in this particular metrical dimension the Dexters are comparable in size to medieval cattle in Yorkshire and have informed the interpretation of the archaeological finds.

The cattle teeth from Ripon showed examples of more advanced wear stages than those recorded for any of the Dexter cows. Age-related arthropathies were, however, infrequent compared to the Dexter cows. Two acetabula, one male and one female, show the bridging of the ilial-pubic border, forming a foramen, as seen in all the older male and female Dexters. There is an area of eburnation on the pubic facet of the female acetabulum but not on the male example. A centroquartal exhibits fusion of tarsal 2+3, exostoses on the proximal lateral border and pitting of the distal lateral articular surface, which appears to be a case of spavin. One distal metatarsal and two proximal first phalanges from Ripon showed eburnation and grooving on the articular surfaces. This arthropathy is not present among the Dexters. A major difference between the medieval cattle and the modern Dexters is the amount of walking the medieval cattle would have done: the cows to summer grazing, the oxen

ploughing, journeys to market and the like. The modern Dexters only had small paddocks to walk about in and therefore less wear and tear on these joints of the feet.

Case Study 5. St Peter's Lane, Leicester

Cattle astragali were recovered from pits, cesspits and wells which had been infilled with domestic refuse by the medieval occupants of the properties in this part of the town (Gidney 1991b). Figure 5: 11a plots the Leicester astragali against the Dexter cows, bulls and young males while Figure 5: 11b plots the Leicester distribution only against the Dexter cows. It is clear that the medieval cattle at Leicester were considerably more petite and gracile in build than even the smallest of the Dexters. Most of the Dexter males fall beyond the range of the Leicester cattle, while the smaller of the Leicester cattle are far smaller than the Dexter cows. While there is close correspondence in size between some of the Leicester astragali and some of the Dexters in Figure 5: 11a, interpretation is not clear cut. Two possibilities may be suggested. The larger Leicester astragali, falling within the Dexter range, could be males while the smaller examples below the Dexter range could be females. Alternatively, all the Leicester examples could be females, with those in the Dexter range being mostly "non-short" and the smaller examples expressing a form of dwarfism, though not the Dexter chondrodysplasia.

The astragalus gives an indication of build, rather than height. Six intact metapodials indicated a height range of 1.07m – 1.14m. The astragali may therefore suggest that the Leicester cattle were of slender build rather than short height.

Coincidentally, the height range of 1.07m-1.14m in Figure 5: 9a was suggested above as the possible cow height range for Lincoln, though the Leicester sample of astragali contains many smaller examples than the 4th century group from Lincoln. The addition of the Dexter males in Figure 5: 11a also shows that the largest Lincoln examples fall far beyond the Dexter range, which will be discussed further in Chapter 6. The contrast between the Leicester and Lincoln astragali shows that there has not been an inexorable, chronological trend towards larger and more robust cattle, as implied by use of the term "improvement". The very petite cattle at Leicester tend to suggest that the "improvement" was in fact in breeding small, gracile dairy cows.

5.5 Discussion

This chapter has found no firm evidence prior to the later 18th century for the concept of herds of cows single suckling calves destined for beef. Instead, some cows appear to have been allowed to suckle calves that were intended for herd replacements or draught but the same cow might be milked in a subsequent lactation. What is clear is that the division of labour between the sexes, proposed in Chapter 4, with women running the dairy cows and men the oxen and suckler cows, may have coloured later preconceptions of cattle domestication. The bias towards male academics in the earlier 20th century may be reflected in hypotheses based on men herding suckler cows for beef in the Neolithic. The 21st century has seen more dispassionate evaluation of evidence for dairying instead, though the implication of the involvement of women remains largely implicit.

In upland areas with minimal arable, the emphasis in cattle production had to be cows for dairy produce. Cattle-raiding was integral to such societies in Ireland, Wales, the Highlands and Borders of Scotland. Although the concept that killing cows was anathema existed in Ireland, in practice many of the stolen cows would have been beefed immediately, particularly those taken in Anglo-Scots border raids: "there was no honour among thieves in the West Marches" (MacDonald Fraser 1974, 89). In such circumstances, the age profile of the slaughtered cows would have been randomly dictated by what was taken as prey. The 16th century apogee of Anglo-Scottish border reiving may have impacted on the longevity of cows. In this respect, it is unfortunate that no faunal assemblages have been excavated from the strongholds of the reiving households in the Borders. Northumberland remains as largely devoid of published faunal remains as it did into the 1990's (Huntley & Stallibrass 1995, 170). Nevertheless, what can be suggested is that sites located in eras and areas where cattle-raiding was endemic, that provide evidence that cows survived to acquire advanced tooth wear, could indicate either that edicts prohibiting the killing of productive cows were obeyed or that the household was able to defend and retain its own property against depredation.

The scale of such cattle raids should not be under-estimated. Henry VIII's "rough wooing" of the Borders in 1544 netted some 20,000 cattle (MacDonald Fraser 1974, 218). By 1587, detailed English proposals were drawn up to reinstate a turf built equivalent of Hadrian's Wall along the Anglo-Scottish border, complete with

fortifications at every mile (MacDonald Fraser 1974, 175). Though this project was never realised, it does indicate that a central authority could be prepared to invest, on a scale that would survive archaeologically, to protect the capital assets of its subjects. The motive would not be altruistic. By decreasing the theft of herds, the tenantry would have more increase with which to pay taxes to pay for such works. In effect, an official protection racket, rather than the unofficial black mail of the reivers.

There are many more instances where archaeologists and zooarchaeologists are failing to collaborate in understanding the value of cattle as a driving force for the construction and re-use of archaeological features: folds for holding droved cattle, pounds for stray cattle, hard standings for cattle marts, large gathering areas for trysts, grandstands for competitive sporting events. The preoccupations of "wall-chasing" excavators preclude such considerations. In this respect Rogers (2008) re-interpretation of urban features is valuable in identifying the location of such features, even though Rogers appeared unaware of their potential significance.

The comparison of the metrical data from the Dexters with those from a selection of archaeological sites has confirmed that cow beef was a staple resource. In chapter 4, it was seen that the Bishop of Durham received 30 cows annually from the tenantry. Given the necessity discussed above to keep herd numbers static to maintain productivity, it can be seen that the Bishop's household could have been provisioned with an equivalent number of cows culled to make room for the new intake. Although renders in kind do feature in zooarchaeological interpretations of assemblages, little thought appears to be given to the practicalities of the system and how it might be extrapolated from faunal assemblages.

No evidence has been found that modern attitudes to cooking and eating beef prevailed in the past. Wheaton-Smith (1963, 66-67) makes the point that the flavour of beef is a factor of age while tenderness is associated with youth. The dichotomy made is between the modern consumer who prefers tenderness to flavour whereas the converse prevailed in the past. In fact, the slow, moist methods of cooking previously described would require well-flavoured beef in order not to be bland. The age of some of the old cow beef, indicated by the tooth wear on archaeological cattle jaws, could imply that the association between flavour and age was both understood and a desideratum, a point rarely considered in interpretations of, for example, Grimes Graves (Legge 1992).

While it is not proposed that the Dexter is a living embodiment of any particular archaeological cattle population, it has been demonstrated that both in terms of metrical data and non-metrical traits, this sample of Dexter cows exhibits points of overlap and similarity with archaeological examples. The consideration of whole skeletons from animals of known life history has allowed the formulation of new hypotheses regarding the aetiology of non-metrical traits, for future application and testing against both modern and archaeological finds. The prevalence of pathologies in these cows, which are interpreted in archaeological finds as evidence for draught cattle, suggests that the zooarchaeological pursuit of the draught ox has masked the frequency of the high-yielding dairy cow with well-developed udder. The example of the Dexters suggests that site-specific re-interpretation of archaeological finds of these pathologies would be of interest.

The archaeological comparanda chosen confirm the gracile, dairy, build of predominantly female cattle represented in food refuse. This preference for cow beef is rarely considered positively by zooarchaeologists, while the intangible dairy products are largely ignored in discussion of dairy based cattle herding strategies.

Chapter 6 will now consider the last member of the herd, the ox as an adult castrate male used either for draught or as an exhibition of the zenith of early modern "improvement", as the term was used from the 18th century to indicate large, early maturing, fat, beef cattle.

Chapter 6: The Ox

Two types of oxen are considered in this chapter. One is the standard ox of long antiquity, providing the draught power for the plough. Such oxen were also used for general haulage, as beasts of burden and, occasionally, as riding animals. The other ox is the immensely fat beef animal of the later 18th and 19th centuries, epitomised by the Durham Ox as the zenith of "improvement".

Both types of oxen are taken to be castrated males for the purposes of this discussion. Langdon (1986, 219-20) cites evidence for tenants employing cows for ploughing but the practice does not appear to have been commonplace. A dichotomy between large teams of castrate oxen on large land holdings and mixtures of oxen, horses, bulls, cows and young cattle by smallholders was noted by Fenton (1969) as still being apparent in hill parishes in Scotland in the 1790's. Such *ad hoc* mixed teams were put together for specific short-term tasks whereas the large teams of matched castrate oxen were worked on a regular basis as the motive power for large scale arable cultivation.

Standard interpretations of the age structure of archaeological slaughter populations usually seek to differentiate, as is the practice today, between livestock reared solely for meat and slaughtered as young adults at optimum carcase size for feed input, and meat as a by-product from mature adults used primarily for milking and breeding. Draught oxen in the past also fell into the latter category. For sheep, Payne (1973) has constructed ideal age profiles for meat and milk producing strategies, against which archaeological data can be compared to aid interpretation of former pastoral economies. Payne (1973) also has an ideal mortality curve for sheep kept primarily for wool. Comparable ideal mortality curves for working oxen kept apart from breeding females are currently lacking. Yet, as noted in Chapters 4 and 5, such a situation is still current today in India, where the dairy animals may not be cattle but rather buffalo, sheep, goats or camels (George 1985, 284-5). Admittedly, of these only sheep and goats were alternative dairy animals to cattle in Britain but ewe's milk, in particular, was an important commodity (Dobney *et al* 2007, 144). This concept of draught being the prime function of cattle rearing has been somewhat neglected in the interpretation of faunal assemblages, despite an abundant literature testifying to the beefing of oxen.

6.1 Historical and Literary Information

The modern herd structure of cattle kept as, and for the production of, oxen today in India can furnish a pattern to look for in the archaeological data. Female cattle, as noted in Chapter 5, are principally kept for generating **male** offspring. This is reflected in the adult sex-ratio, with a high proportion of males to females, the converse of buffaloes kept for dairy production (Doornbos *et al*. 1990, 33). The latter pattern is a standard expectation in the interpretation of faunal remains, whereas the former is not.

Such a scenario, emphasising the predominance of male cattle on a 14th century arable estate, may be depicted in the scenes of rural life in the Luttrell Psalter. Here, the cattle represented are four plough oxen and one bull. There are no female cattle or youngstock. The explanation for this may lie in the milking bail, which is populated with ewes being milked, together with the ram and bell-wether (Backhouse 2000). This apparent ratio of exclusively male cattle to mostly female sheep on a Lincolnshire estate is of interest to the supply of stock to Lincoln, where the medieval cattle mandibles suggest "the presence of roughly equal numbers of adult and elderly animals, with low proportions of subadult individuals" (Dobney *et al* 1996, 31) while the medieval sheep mandibles exhibit "a clear trend towards subadult and adult animals, with very few young animals represented in the sample" (Dobney *et al* 1996, 40). This slaughter pattern could indicate plough oxen and milking ewes culled from local estates run precisely on the lines depicted in the Luttrell Psalter.

This suggestion of the primacy of the plough ox over the dairy cow, where the land was suited to arable, is one reason why the interpretation of cattle bone assemblages which include calf bones as evidence for a dairy economy, necessitating the preferred slaughter of bull calves, may be in need of revision. The dams of the calves may indeed have been milked but the slaughtered calves may have been heifers, as discussed in Chapter 3, allowing the bull calves to be reared. Only in modern industrial society, with no reliance on animal traction, is slaughter of infant bull calves and rearing of all heifer calves a standard option.

i. Up Corn, Down Horn

Agriculture follows cycles of prosperity between arable and pastoral enterprises, summed up in the phrase "up corn, down horn". However, the indissoluble link between arable and pastoral farming was the supply of plough oxen. Whittaker (1988, 3) emphasises the interdependence of farmers and herdsmen and the relationship between the value of grain and fodder in the classical world. Jameson (1988, 107-112) presents the evidence from a range of classical sources for speculation on the price relationships between cattle, wheat and ox-hides.

Rather more evidence survives from the medieval period. Farmer (1969, 14) notes for the 13th century a close correlation between the average price of wheat sold by manors and the price of oxen bought by them. The detailed accounts of manorial income and expenditure also show the rapidity with which arable could be converted to pasture once cereals ceased to be profitable (Davies 1978, 114-5). Such flexibility was possible where grazing of the fallow field was normal and the waste was adequate for pasturing increased headage. While the ploughman might appear redundant, the fact that labour was available that was experienced in livestock husbandry could have helped facilitate such swift change in policy, for example from rearing bull calves and slaughtering heifers to *vice versa*.

The ox himself always retained his value as beef and Walter of Henley's dictum that "when the oxe is old with xd (*sic*) of grasse he will be made fatte to kylle or to sell for as much as he coste you" (Oschinsky 1971, 319) is often cited. How much grass is represented by 10d is another matter that is not discussed. Taking Oschinsky's (1971, 144) suggested date of 1286 for the composition of Walter of Henley's treatise, the national average price of an ox that year was 10s 8d (Farmer 1969, 3). The rapid recuperation in body weight of store stock turned out onto spring grass has been discussed in Chapter 5. Here it can be seen that Walter's 10d was a worthwhile investment in finishing an old ox.

The application of "down corn, up horn" may be seen in the later medieval decline in arable acreage, and hence numbers of cull oxen available for the urban beef market. This may be a contributory factor to the general trend for a chronological decline in the numbers of cattle bones from Anglo-Saxon to later medieval deposits, and a concomitant rise in the proportion of sheep bones, as seen, for example, at Lincoln (O'Connor 1982, 11). "Up horn" may be reflected in the numbers of calf

bones, discussed in Chapter 3, as possible evidence for increased dairy-based cattle-keeping from the 15th century.

ii. Status of oxen and ploughmen

In Christian communities heavily dependent on bread as a staple food, the verse of the Lord's Prayer "Give us this day our daily bread" would have had especial significance. This is reflected in the ambivalent status accorded to the ox herd and the ploughman. Literary examples include Aelfric's *Colloquy* of the 10th century, where the response to the Master's query as to which of the secular arts is of greatest importance is given by the Councillor as "Agriculture, because the ploughman feeds us all" (Swanton 1993, 174). In practice, the ploughman remained low in the overall social hierarchy, bound to the land by customary tenure, but of high regard within rural communities, where graduation to ploughing with oxen marked the break with childhood and the transition to manhood (Fabre-Vassas 1997, 80).

Ploughmen and oxen also appear in the burgeoning fictional literature of the 14th century, where they are used as indicators of lowly social status. Examples include Langland's eponymous *Piers the Plowman* (Skeat 1965) and the romance *Octavian* (Salter 2001, 82-95). By the 15th century, the use of horses in agriculture had become synonymous with progressive and intelligent handlers, whereas those still using oxen were caricatured as being dull and slow-witted like their charges (Langdon 1986, 275).

At the practical level of feudal tenancies, Boldon Book (Austin 1982) in the late 12th century is more concerned with the numbers of ploughs and harrows in each settlement and the area of land to be cultivated. However, numbers of oxen are specifically mentioned with regard to carting wine for the Bishop, detailed in Appendix 6: 1. From this list, it can be seen that in most settlements the responsibility for providing the oxen for carting wine was attributed to a named tenant, usually with the largest holding. Of the 13 teams of oxen, there are 8 teams of 4, 1 team of 6, 3 teams of 8 and 1 team of 12. Such large teams contrast with the medieval illustrations, below, which illustrate a maximum team of 4 oxen. The explanation is generally held to be that the larger numbers of oxen were required to do the task but this was achieved by sharing the workload between smaller teams, so that each yoked pair was regularly rested (Fenton 1969, 27). Providing the labour of the oxen was a customary due of the tenancy but the oxen remained the property of the tenants. In contrast, the

cow for metreth, discussed in Chapter 4, was a render in kind, of anonymous ownership, by the entire settlement. The 74 oxen needed to cart wine suggest the large size of the Bishop's household and poor road conditions, and contrast with the total render of 32 cows for metreth.

iii. Age of castration and life span of oxen

In contrast to classical authors, such as Varro recommending castration at two years old (Hooper & Ash 1934, 377), the medieval accounts are curiously reticent about the timing of castration for oxen (Langdon 1986, 293). One document that at first seemed to answer the question of castration is the *Ménagier de Paris*, a 14th century treatise. Crossley-Holland (1996, 52) gives this translation: "Josson (the oxherd) for the oxen and bulls (his duties were far ranging: castration of young bulls and pigs; helping calving cows; caring for young calves)". However the same passage translated by Power (1928, 211) merely states "Josson the oxherd (to look) to his oxen and bulls". The original French is given as "a Josson le bouvier des befz et des thoreaulx" (Brereton & Ferrier 1981, 130). The implication is certainly there that the oxherd was responsible for castration of young bulls but the original passage is not as explicit as Crossley-Holland's interpretation. However, the simple fact that, in this instance, the oxherd was also responsible for the bulls strongly suggests that the castration of bulls for oxen took place when the animals were young adults, rather than as calves. This has implications for the differentiation of entire and castrate males in the archaeological record. If castration was delayed until after the earlier fusing bones had fused, these would overlap the robust male range. However, later fusing bones *from the same animal* could continue growth, without the check provided by the male hormones, extending the male size range range.

Thomas Tusser, writing in the 16th century, gives a little more information. In May his advice includes:

"Keep ox fro thy cow, that to profit would go,
Lest cow be deceived, by ox doing so;
And thou recompensed, for suffering the same,
With want of a calf, and a cow to wax lame." (Hartley 1969, 69).

This certainly suggests an ox gelded as a young adult and still displaying bull-like behaviour in mounting the cow. Tusser gives the time of year for this operation as

September: "Now geld with the gelder, the ram and the bull" (ibid, 96). Tusser, however, also recommends the operation for calves in January:

Geld bull-calf and ram-lamb, as soon as they fall,
for therein is, lightly, no danger at all.
Some spareth the t'one, for to pleasure the eye,
to have him shew greater, when butcher shall buy." (ibid, 127).

The inference of this passage being that both calves and young bulls were castrated for oxen and that the latter were particularly reared for beef rather than draught. This has very interesting implications for the interpretation of the sex ratio in 16th century assemblages. Potentially there might be evidence of cows, early and late castrates and bulls.

In the 19th century, surplus males selected for castration in the Chillingham herd were at least three years old. It was found to be easier and safer to catch adult beasts in a specially constructed trap than to operate on infant calves with very aggressive and protective mothers. Such castrates were shot for beef at six to eight years old (Whitehead 1953, 48).

Two to three years therefore seems to be a consistent age when selection was made among the stots to separate out those for beef, those for breeding and those for castration and training as oxen. At this age, entire males could start to become troublesome, by challenging established King Bulls with a possibility of winning the encounter. The stots would have developed the “bull’s neck”, giving a good grip to the yoke.

The Welsh laws indicate that an ox was in its prime from the second work year until the sixth work year. The ox increased in value when yoked at about three years old, the first work year, but did not decrease after about nine years old, if kept beyond that age (Wade-Evans 1909, 219-220). Ten years old would seem a suitable age to cull for beef and realise the capital necessary for a replacement ox. The treatises on estate management emphasise regular inspection of livestock to remove old and feeble animals for sale (Oschinsky 1971, 439), suggesting that manorial cattle were culled while still saleable at a profit.

The position of the ox in the larger teams also had a bearing on longevity. Fenton (1969, 38) observed that a good lead ox in the late 18th century Aberdeenshire teams of 12 could be kept until 12 years old because the smooth turning of the entire team at the end of the furrow and general steadiness of draw depended on him.

Conversely the London market for beef led to the large teams of oxen in Sussex, as observed by Cobbett (Cole & Cole 1930, 879-80). The logic here was the balance between achieving the workload whilst fattening the oxen. In a large team no single animal was over-exerted (Fenton 1969, 42). Even when oxen were being kept primarily for beef, some traditional farmers saw no point in keeping oxen idle when they might profitably draw the plough for two years without impacting on the quality of the beef (Fenton 1969, 44).

iv. The Fat Ox

William Cobbett is an invaluable chronicler of the early 19th century, when the draught ox was being supplanted by the fat ox. The description in 1834 (Cole & Cole 1930, 879-80) of the small cattle bred in upland Wales being sold off the hill and moving into England to grow into the fine and fat working oxen of Kent and Sussex is a classic example of a stratified livestock production system, with neither end of the supply chain being aware of the conditions in which the cattle were kept. Cobbett emphasises that such oxen could not be bred profitably in the counties where they were worked, nor could they be fattened where they were bred. The variation in phenotype between closely related bulls reared on such contrasting planes of nutrition is illustrated by Cochrane (1946, Plate IV). Such systems of supply may well be indicated by assemblages of large cattle bones from lowland arable regions with contemporary assemblages of small cattle bones from upland dairy regions. The difference in phenotype could simply reflect the size contrast between the well-fed castrate male and the dairy conformation cow, rather than genotype or "improvement".

In largely arable areas, both the draught ox and the fatting ox were seen as invaluable sources of manure for fertiliser. The practice of agisting steers on root crops, with the beasts treading straw into muck, remained integral to East Anglian farming (Rider Haggard 1899, 197-9; Williamson 1942, 194) until artificial nitrogenous fertiliser became readily available post-war. Less commonplace was the use of oxen to tread the cob for wall building. Plates 6: 2 a-b show a modern attempt to revive this practice, using Dexters, for the renovation of historic cob walling in Devon (Bunning 2007, 14-15; Alison Bunning pers. comm.).

The rise of the fat ox in north-east England has been summarised by Gidney (2009b), with the most famous example being the Durham Ox (Comben 2007).

Although this was an animal for exhibition, travelling in a carriage with the owner's wife and becoming as "familiar as a lap-dog" (Comben 2007, 15), he remained nameless and therefore beef on the hoof. The fame of the Durham Ox on his 3000 mile journey prompted many imitators but none surpassed him. This exceptional animal was an advertisement for fat, producing 11stone 12lbs (c. 70kg) of loose fat when slaughtered at 11 years old (Comben 2007, 54). The Durham Ox marks the divide between the demise of the working ox and the rise of the fat butcher's beast. However, even at the height of the obsession with massive fat oxen, some correspondents queried the profitability of the practice, with detailed reports showing that smaller cattle fattened more readily than larger ones and returned more profit for the proportion of feed consumed (Young 1797, 380-1; 604-8).

A major change, commencing in the 18th century, was in the concept of beef as a commodity in its own right, distinct from the living animal, and the associated social repercussions (Rimas and Fraser 2008). It is this change in mindset that lies behind the whole rhetoric of "improvement" in cattle breeding and in critiques of "unimproved" agriculture, whether ancient or modern. This is the millstone of received wisdom that needs to be discarded for the interpretation of archaeological assemblages, rather than trying to shoehorn the data into an inappropriate economic model.

In tandem with commoditisation was post-medieval capital investment of profit in the land and the livestock. This contrasts with the approach of medieval magnates, who expended any profit from the demesne on high living and conspicuous display (Langdon 1986, 269). Any advantage gained by, for example, the replacement of oxen with horses for ploughing, was seen as a cost-saving rather than an opportunity to increase production (Langdon 1986, 277). This difference in approach further illustrates why "improvement" in the modern sense was not a concept in medieval and earlier agriculture.

v. Eating Quality of Ox Beef

Despite the evidence presented in Chapter 5 for consumption of cow beef, the desirability of beef from oxen may be suggested by the transition from the French word *boeuf* for the live ox into the English *beef* for the meat of the animal. The victualling of war bands in Ireland, and probably upland Britain, by an accompanying herd of cows was discussed in Chapter 4. The more regimented army of the medieval

English crown was provisioned with beef on the hoof, explicitly oxen. The early 14th century murrain of cattle impacted negatively on Edward II's Scottish campaign. The oxen driven to Berwick to supply the English army not only died of murrain but also spread the disease in the Borders, whence it escalated into Scotland. The result was the abandonment of the campaign from want of oxen to feed the troops (Newfield 2009, 165 & 169).

The consideration of beef in Chapter 5 demonstrated that medieval consumption was based on principles differing from those now current. The pre-eminence of beef in feeding a large assembly is demonstrated by the purveyance made for King Richard while at the Bishop of Durham's palace in London on the 23rd September 1387, which commences with 14 salt oxen and 2 fresh oxen (Austin 1888, 67). This salt beef, also known as hung beef, was a staple of the dead garnisture of castles and similar large households. At a less socially exalted level, the account rolls of Alan Plukenet, constable of Dryslwyn castle (Rhys 1936, 37-63) give an invaluable insight into the provisions remaining in store when the castle was captured by the English from the Welsh lord, and subsequent victualling by the English. These accounts concern the dead garnisture, or preserved provisions kept in store, not perishable foodstuffs. Amongst the goods in Dryslwyn which belonged to "Res son of Mered" were 147 beasts and oxhides, which were subsequently sold by Alan Plukenet and recorded in the account roll for 1287-89. A further 23 beasts "from what was left of the stores of Res son of Mereduc" were sold and accounted for in the roll for 1289-90. The preparation of beasts for the dead garnisture is described further in the account of Walter de Pederton (Rhys 1936, 133). Here 70 oxen and cows were bought for the larders of Dinevor and Dryslwyn castles at 5s 6d each and a further 2d a head was expended "on the slaughtering and salting of the same animals and preparing them for the larder". Twenty ox carcases were also purchased at the same time. Subsequently (Rhys 1936, 149), Walter de Pederton's account records the purchase of firewood "to dry the meat for the larder". Later, the Prior of Carmarthen's account (Rhys 1936, 225) explictly costs together the purchase of 41 oxen with "the slaughtering, preparing and salting of the same in the larder, with the firewood bought to dry the aforesaid meat". The practice continues in William de Rogate's account (Rhys 1936, 331) which sums together "37 ox carcases.....together with the salt and the pay of the butcher doing the larderwork this year".

From these accounts, which appear to represent standard practice, the laying down of beef for the dead garnisture was clearly an annual, seasonal event. Most of the accounts are explicit that it is simultaneous with the slaughter of the pigs received from pannage, indicating a time in late autumn to early winter. This corresponds with the artistic representations of seasonal work in November-December, noted below. Into the mid 19th century, Scotland retained such a widespread tradition of salting whole carcases of beef and an associated cuisine of broth and boiled meat (Perren 1978). It was also known in England as "Hung Beef", preserved by salting and drying, either with or without smoke (Beeton 1861 facs., 293). Beeton's instructions appear to differ little from medieval practice as the beef should be hung for 3 or 4 days then salted "in the usual way", either by dry salting or by brine, and afterwards hung in a warm, not hot, place for a fortnight or more, till it is sufficiently hard when " it will keep a long time".

The fact that much medieval beef was preserved in this way has obvious connotations for the method of cookery, being ideally suited to the warm, moist cooking deemed necessary for cold, dry beef. The medieval designation of the humour of beef as cold and dry may in fact be a practical recognition of the character of hung beef. The modern concepts of "prime" fatstock and "prime" cuts of meat have no relevance when the whole carcase was so hard that it could keep for years. In turn, zooarchaeological interpretations of age at death and eating quality of meat can be seen to be spurious if no cognisance is made of the probable presence of such hung beef being represented in faunal assemblages. Some of the queries posed of the Flixborough assemblage and the provisioning of *wics* (Dobney *et al* 2007, 140-141) could be addressed by understanding the place of hung beef in feeding the menial members of large households.

By the mid-16th century, medieval traditions of cookery were in decline and roast fresh beef had become commonplace (Rogers 2004, 11), though boiled beef, particularly salt beef, remained popular (Rogers 2004, 19). By the 18th century, roast beef was indelibly linked with jingoistic patriotism (Rogers 2004, 76-9) and the breeding of large, fat oxen, though the eating quality of the meat was not considered important. Meg Dods, cook to the Cleikum Club in Edinburgh, writing in 1829 was scathing of beef from such large, over-fat "oxen which are better fitted to the tallow-chandler than the cook" (Dods 1988, 93). These fat cattle were produced as a commodity to make profit for the gentlemen breeders, and the butchers, at the

expense of the consumer, the industrial poor. Because of the high fat content of these carcases, killing out percentages of up to 80% were recorded (Proud & Butler 1985, 27). The poor were paying for a lot of fat and little lean.

While the beef itself is long gone, the bones from culinary waste which show continuance of the unimproved, small cattle alongside the post-medieval improved, large cattle may suggest, as one interpretation, that the eating quality of the unimproved animals may have been considered superior and preferred by those who could afford to choose.

vi. Roast Ox

Despite Fothergill's (1903) assertion that roasting a whole ox was a relic of barbarism dating back to an unknown age, the custom appears to have been particularly associated with landmark events in the reigns of Queen Victoria and King Edward VII. An earlier 19th century ox roast formed part of the celebrations for the coming of age of John Pole in 1829, drawn by George Cruikshank (Paston-Williams 1993, 240). This depicts two massive oxen on the spit, with heads including horns left on the carcase and only the metapodials and feet removed. Minwel Tibbot (1985-6, 50) illustrates an ox-roasting at St Fagans, Glamorgan, c.1900. Rather better attested is the 1902 ox-roast held in Darlington to celebrate the coronation of Edward VII. The live animal was photographed, together with the ox-roasting committee (Dean & Clough 1974). It is particularly interesting that, though it is a Shorthorn, it is a perfectly normal animal, in good condition but with none of the excessive fat associated with the earlier 19th century Shorthorns. It took from 7pm one day to 3pm the following day to thoroughly cook the animal, using six large braziers of coal and a traction engine turning the spit. The nature of the fuel and the motive power for the spit perfectly demonstrate why the whole ox-roast, despite an historical glamour, was such a recent phenomenon. In both early 20th century examples, the skin and metapodials were removed from the body, though the head with horns was left attached and neither head was skinned.

Darlington is proud of its ox-roasting tradition, with a further example in 1911 for the coronation of George V (Darlington & Stockton Times 7/6/13, 20) and the most recent on 8/6/13 to commemorate the 150th anniversary of the covered market. This modern “roast” ox was in fact baked in an enclosed oven, Plates 6: 9a-b. (Bones of one hind leg were acquired but are still in prep. July 2013)

Remains of such roast oxen might be an alternative interpretation for isolated finds of relatively complete post-medieval carcases, other than murrain deaths. Roast ox should lack metapodials and feet and could show scorching on distal radii and carpals, distal tibiae and tarsals. Roast ox should be associated with a massive community feast, such as the coronation of a monarch or the coming of age of the heir to a great estate, with documentary evidence balancing or confirming such an interpretation.

vii. Artistic Representations

Classical art abounds with images of oxen carting, ploughing and threshing, with examples given by White (1978, Plates 11, 13 and 19). Less common is the ox as a pack animal, laden with produce for sale at market (White 1978, Plate 20). These draught oxen, and the bull in the suovetaurilia (White 1978, Plate 22), are shown as approximately chest high to their human handlers. The pack ox is roughly waist high to its handler, but this is a provincial Germanic, not a Mediterranean, depiction. The ritual model plough team of a bull and a cow found at Piercebridge show the pair standing below the waist height of the ploughman (Johns 2011, 137). This team resemble a recent pair of short-legged Dexter oxen in height and build (Curran 1990, 13). While these are but a few random examples, there is a suggestion of a trend contrary to Bergmann's Rule, with a decline in the height of Roman cattle from the Mediterranean to the northern provinces, also observed in the bones themselves.

In medieval art, plough oxen, the nativity ox and the ox of St Luke are particularly well represented. Rather than the Classical scenes of sacrificial animals, later medieval pictorial representations of the Labours of the Months include the slaughter of the ox in November or December instead of, or as well as, the slaughter of the pig (Pérez-Higuera 1998, 63). Despite differences in style and increasing naturalism spanning several centuries from the 9th century (Pérez-Higuera 1998, 12), mid 11th century (Basing 1990, Fig. 4), the mid 12th century (Hartley & Elliot 1931, Plate 7), the 14th century (Basing 1990, Figs 3 & 6) and the 15th century (Longnon & Cazelles 1989, 4; Hartley & Elliot 1925, Plate 19; Bartlett 2001, 101), the convention remained to depict labouring oxen as approximately waist high to the ploughman and goader and with the upright "crumpled" horns described in Chapter 4 for the cows. There is surprisingly little difference in colour and conformation between the 14th century English oxen in the Luttrell Psalter (Backhouse 2000, 16-17) and the early

15th century French oxen in the Très Riches Heures du Duc de Berry (Longnon & Cazelles 1989, 4), other than artistic style. Even the Duc de Berry, it would seem, did not require his demesne oxen to be depicted as "bigger and better" to enhance his magnificence. Other than perhaps the distinctive horn shape, it would be possible to find modern Dexters to replicate the Luttrell oxen.

Less commonly discussed in commentaries on the Luttrell Psalter is the depiction of a riding ox (Dent 1974, 32). Though Dent describes this as a white ox, it is in fact a red ox with gold horns, much longer than those of the plough oxen, in the facsimile of the Luttrell Psalter (Brown 2006b), and the bridle and reins are clearly visible. Brown (2006b) suggests that the rider appears to be clerical, though the forked staff and broad-brimmed hat are signifers of the pilgrim. The colour of this ox may be connected with the vocation of the rider, as cattle in Bestiaries are frequently depicted as this bright red, representing the blood of the passion, where the beasts are used as allegories of Christ (Barber 1992, 88-93). By the 16th century "riding the cow" had become an expression indicating a proverbially absurd mount (Jones 2002, 165), though Jones failed to find any medieval image illustrating this concept. The beast being ridden in the Luttrell Psalter is clearly delineated as a castrate male, so is unlikely to be a humorous allusion to "riding the cow". Though Dent (1974, 32) draws attention to this image, it is in support of a statement that "ox-riding was in fact unknown in England". The very fact that a ridden ox is depicted in the Luttrell Psalter indicates that the image had a contemporary relevance, even if this is not clear to modern commentators.

The use of the ox as both a pack and riding animal is more common in Eastern art. Johns (2011, 142) illustrates a post-medieval Japanese woodblock print of oxen laden with sheaves. In Indian art, 18th -19th century illustrations (Johns 2011, 45 & 186) show Nandi, the mount of Shiva, with a bridle comparable to that seen on the Luttrell Psalter riding ox. The ox, usually a water buffalo where taurine cattle are uncommon, was the conventional mount of sages and wise men in the art of the Far East, (Johns 2001, 50-51). Such associations of the divine, the educated and the religious mounted on oxen may be pertinent to the interpretation of the Luttrell Psalter riding ox.

Riding oxen were also used in 19th century Africa. Watts (1999, 22) reproduces an engraving of Sir Samuel Baker riding an ox during his search for the source of the Nile. The continuing use of pack and riding oxen in Africa is illustrated

in Figure 6: 1 by a photograph taken in 1934 in the Sudan (DUL SAD 705/4/5). Stoppard-Rose (2013, 57-72) discusses the widespread use of riding oxen in Africa, even as European cavalry mounts, in regions where horses could not be employed due to "horse sickness". One of the advantages of the ox as a riding animal is that once trained the ox never forgets, even if only worked in this way at irregular intervals (Stoppard-Rose pers. comm. 27/5/13). Of interest for archaeological finds of complete cattle skeletons is the fact that such African riding oxen were not slaughtered for food but buried after dying naturally (Stoppard-Rose 2013, 58). This multipurpose use of oxen for riding and pack animals may help to explain mentions of oxen in the mobile dairy-based cattle raiding societies of Ireland, Wales and Scotland. While necessary for arable cultivation, at slack times in the arable calendar, such oxen could have carried the necessary dairy equipment and the dairy-maids.

One of the latest paintings of working oxen is of a windmill being towed to a new site by 86 oxen in 1797 (Hall & Clutton-Brock 1989, 81). However, the decline of the draught ox and the rise of the fat ox stimulated a new genre of art commencing in the later 18th century, to publicise these vast animals and their breeders. Paintings of outstanding beasts were commissioned for engraving and mass distribution. Representations of Teeswater cattle, ancestral to the improved Shorthorns, show recognisably naturally proportioned beasts, despite the killing out details enumerating 16 stone (c. 100kg) of tallow (Spargo 1989, 83-4). Thereafter the depiction of subcutaneous body fat became integral to such paintings and artists appear to have been expected to enhance this aspect of the animal. Such desirability and representation of excess body fat on these early modern oxen is in stark contrast with the fit but not fat working oxen depicted in medieval art. It can therefore be suggested that transposing the ideology associated with these over-fat oxen to earlier time periods is inappropriate.

viii. Ox Sports and the Exhibition Ox

Two types of ox sport survive today. The stolid oxen of western Europe are more suited to trials of strength and stamina. Idi Probak in the Basque region of Spain is one such trial of strength, with teams of oxen competing to drag stones of specific size and weight over a set course on hard standing. This appears to have originated from bets between farmers over whose oxen were the stronger. In Asia, where oxen

are of lighter build and the ground is dry, ox racing is the preferred sport. For this, yoked pairs of oxen towing small sleds ridden by the drivers are raced with the driver using the goad to encourage the team. The action is fast and furious, with thrills and spills. Palin (2004, 22) illustrates this for Pakistan and Johns (2011, 152) for Indonesia. The cattle are described as bulls by both Palin and Johns but, from the sheer number of race entries, these cannot all be breeding bulls. The fact that the teams are yoked strongly suggests that, if entire, the cattle are stots and that the racing forms part of the selection, assessment and training of those beasts destined for draught work. The experience of Bantu's first attempt at dragging a weight strongly suggests that this type of ox-racing is exploiting a similar reaction.

Both these ox sports remain popular because of the associated betting. Similarly, the outstandingly large exhibition ox as a money-raising attraction commenced, as described above, with the Durham Ox. The massive exhibition ox touring the agricultural shows of the 1950's was a classic Shorthorn steer, teamed with a Dexter heifer to emphasise the size difference, Plate 6: 10.

6. 2 Data from Modern Herds

i. Training of oxen

Since draught oxen were already rare in Scandinavia in the 1960's, the training of a pair of oxen formed part of the research design for an experimental project, ploughing with a replica ard (Hansen 1969). It was discovered that the cattle used in 1962 were too big, as the point of draught was much higher than that of the animals that had originally pulled the ards. To rectify this, a pair of Jersey bull calves were obtained and castrated, which grew to 1.47m and 1.33m withers height by the time they were trained, again taller than their archaeological predecessors. Despite clear training objectives being set, these were not achieved. In particular the oxen had to be led rather than being controlled by the ardman (Hansen 1969, 73-4). Records were kept of the cost of rearing the oxen to training stage, and the labour input for training. The conclusion was that it would have been more cost-effective to have purchased grown animals for training (Hansen 1969, 92). For many years this project influenced discussion of the time and costs implicit in training oxen.

More recently, a teaching video, produced by the Centre for Tropical Veterinary Science in Edinburgh, on the training of oxen for Third World countries,

demonstrated the time required. Where the handlers had no previous experience of using draught cattle, it took three full six-day working weeks for the handlers and cattle to learn to work together and for the handlers to make both the training yoke and the working yoke with associated padding. Assuming 7 hours actual working time each day, this would equate to c. 124 hours, about half the 250 hours training estimated by Hansen (1969, 92) for the Jersey team.

Johannsen (2005, 47) has queried the amount of time and effort involved in training draught oxen, citing a range of historical and modern examples of a younger animal being yoked with an older, experienced, animal and rapidly learning "on the job". However, this opinion ignores recurrent situations where novice ox teams would have to be trained. In a time of arable expansion, such as is known to have happened as a rapid response to either market-led demand or environmental factors in both Roman and medieval Britain, the demand for plough oxen could have outstripped the supply of experienced animals for training younger oxen. A further situation where the training of novice ox-teams would have arisen, in both the Classical and medieval worlds, would have been in the aftermath of one of the periodic devastating episodes of murrain, or contagious, fatal cattle disease. The *Anglo-Saxon Chronicle* (Ingram 1929) suggests a virulent epidemic once in a generation, or roughly every thirty years. While murrain is a generic term, historical accounts of cattle plague, probably rinderpest, in the 18th century (Jones 1978, 22-3) indicate the far-reaching consequences on the availability of replacement stock in the aftermath. Plague and contagious disease among the human population would also have reduced the numbers of people looking after livestock, which notoriously died of neglect in the aftermath of the Black Death. Kohn (1998) details all the known instances of epidemics of human pestilences. Many of these would have had knock-on effects on the livestock populations, with loss of skilled cattle breeders, herders and ploughmen among the rural population. Time and again, situations must have arisen where novice handlers had to train ox-teams and novice pairs of oxen had to be trained to the yoke. Indeed, Columella's instructions on the training of oxen are explicitly for a situation where no trained oxen are available, with a different method described where an untrained beast is teamed with a trained pair (White 1978, 80-81).

Following on from Hansen's (1969) precedent, two non-short Dexter steers bred in the Zanfara herd, Bantu and Wellington, were reared as a team of oxen for the Anglo-Saxon farm at Bede's World, Plate 6: 3. The near-side ox traditionally had a

single-syllable name and the off-side ox a similar but two-syllable name, so the correct animal responds to a verbal command (Watts 1999, 17). The author was unaware of such conventions when Bantu and Wellington were named.

Bantu and Wellington were kept until 11 years old. At the start of the training project, it was intended to keep a photographic record of their growth and development. This was only partially successful and there are gaps in the record. Plate 6: 4 shows one steer as a weaned stirk. At this stage they were typical scrawny hill-bred "black cattle". Note the "horns as long as the ears". This is a standard description in the Welsh Law books and equates with modern yearling Welsh Black steers (Sheringham 1982). A similar concordance of horn and ear length in yearling Dexters has been regularly observed in the Zanfara herd, suggesting that such an equation of developmental stage with an age cohort would have been more broadly applicable to archaeological cattle.

The contrast with the size and build of these oxen at 11 years old was striking. For example, Plate 6: 5 of Bantu and a related female demonstrates the extreme range of phenotype in one genotype caused by dwarfism in the female and early castration in the male. This pair demonstrates that archaeological interpretations of "improvement" solely in terms of the presence of larger animals can be misleading without consideration of such contributory factors.

The two steers had basic halter training and some experience of dragging an object before going to Bede's World, where they received regular training sessions. The training yoke used in Plate 6: 3 is known over a wide area of Central Europe and Sweden (Fenton 1969, 17-18) but there is no evidence for its use in Britain. This was replaced by a withers yoke of traditional design, Plates 6: 6a-b. The necessity for minimising public risk meant that Bantu and Wellington were always led on halters, which tends to slow oxen down for real work (Watts 1999, 17). Like Hansen's team, they were never taught to walk with the driver behind, using verbal commands and controlling their pace with the rod or pole.

As shown in Plate 6: 3, Bantu and Wellington did do some rudimentary ploughing at Bede's World. The novelty of working oxen on Tyneside generated much coverage in the local press and an invitation for the oxen to take part in the Royal Tournament in London. Despite being advised by the staff at Bede's World, the army handlers, used to horses, insisted that Bantu and Wellington should travel in separate compartments. Bantu rapidly smashed the partition to be with Wellington on

the journey. This problem may have resulted from castration as a calf, since Bantu appeared to retain a calf mentality and was distressed if separated from either his mother or Wellington, or familiar handlers, hence Bantu might not have been deemed suitable for retention as a draught ox in the past. One reason for sorting and castration of the stots at 2-3 years old might have been that such young entire males would have outgrown this calf-like need for specific companions. Alternatively, Bantu might indicate part of the reason for yoking female cattle. Bantu would possibly have worked more successfully if he had learnt by being yoked to his dam. Bartosiewicz (*et al.* 1997, Figure 6) illustrates an example of a modern mother and son team.

Two heifers were also trained to walk in the yoke for promotional purposes, Plate 6: 7. Although unplanned at the time, the female team mirrored the Luttrell and du Berry ox teams in having one red and one black animal in the pair. In contrast to the steers, the heifer team took comparatively little training to walk together in the yoke, as both were already halter trained and had met the public at large. As Fenton (1969) noted, small tenants made do with such young stock in the yoke when necessity dictated.

The time, effort and financial cost involved in the training of Hansen's oxen, those on the training video and Bantu and Wellington at Bede's World partly reflect the modern lack of handling of infant suckler calves and the lack of a large age cohort from which animals could be selected as team mates. The insistence in the medieval didactic treatises on friendliness as an attribute in the calves chosen for rearing, together with the regular handling in the gradual weaning from the dam, described in Chapter 3, could have simplified the training of castrate males for oxen.

Two short-leg Dexter bull calves,born in the Rustikop herd in 1996, were generously donated by the breeder to Bede's World as yearling entire males, where they were promptly re-named Oswald and Oswin and castrated. This team was still alive in 2007, Plate 6: 8a-c. They were trained to the yoke but did less work than Bantu and Wellington. The farm manager reported (Chris Fitzgerald, pers. comm.) that they appeared to become arthritic comparatively young. It is not clear whether this was the result of too much draught training too young, over-feeding and associated excess weight or a side effect of the Dexter dwarfism. What is beyond doubt is the difference in conformation of the two pairs. While part of the difference in size is the contrast between short and non-short, some of the build is the result of the different age of castration. Oswald and Oswin were more masculine in appearance

and did not appear to have continued growth to the same degree as Bantu and Wellington. The latter were more feminine in appearance but roughly half as large again compared to their dams.

Despite the close relationship, Bantu and Wellington were not a perfect matched pair. Similarly Parsnip and Carrot from the Vycanny herd, discussed in Chapter 3, were intended to be a team but ended up too mismatched in size so were beefed. This could be one explanation for the culling of young male cattle in the past, when no matching partner for the yoke was available. Such a necessity of level size in draught teams would have been a strong disincentive to individual herds breeding cattle of differing stature to those of everyone else. One contributing factor to the wide scale distribution of large improved cattle in the 18th century is that the ox had been largely superseded by the horse for draught work.

6.3 The Dexter Ox Reference Skeleton

It was not possible to obtain the skeletons of the Dexter oxen Bantu and Wellington in the wake of post-BSE and Foot and Mouth legislation. The reluctant decision was made in 2002 to send this pair, though in good health, on the OTMS as it had become financially crippling to keep them. Despite the lack of skeletons, much useful information was gained on the nature of the ox castrated early. It is almost certain that epiphysial fusion had been substantially delayed as both were still growing at 11 years old. For example, the yoke that was made for them in 1996, Plates 6: 5a-b, was a very tight fit in their later years.

Both steers were sired by Juglans Nigra, discussed in Chapter 2. Wellington's dam was Chalena, discussed in Chapter 5 and Bantu's dam was Jaqueena, daughter of Chalena. It can be seen that these two were closely related to other members of the Zanfara herd, discussed in Chapter 3.

i. Dexter X Jersey Steer

Only one steer skeleton was obtained that is comparable to Bantu and Wellington. Hadza was a Jersey sired bull calf from a Dexter dam, Vycanny Grafted Peach, born 14/3/91 and double suckled with Bantu on his dam Chalena. The castration and early management of Hadza followed that of Bantu and Wellington and, despite the difference in breeding, the three steers formed a level group. Hadza

was beefed at 3 years 8 months old (20/11/94). Hadza is therefore a proxy for the growth and development of Bantu and Wellington to this age, though he remained in the Zanfara herd and was not subject to the same yoke training. Hadza was only eight months older than the barren heifer Dusty (Chapter 3) when beefed, and with Dusty forms the crossover point between growing youngstock and working adults. Although a single skeleton, the description follows the order established in the preceding chapters, for ease of comparison.

ii. Skeletal Ageing

The stage of epiphysial fusion for Hadza is compared in Table 6:1 with that for heifer Dusty, previously discussed in Chapter 3. It was anticipated that the age difference of only eight months between the two animals would not be readily detectable. However, it is clear that the sequence of fusion in Hadza, the older of the two, is not as advanced. Fusion lines on the distal metapodials are still clearly visible and only fading on the distal tibiae. Epiphyses that are fusing in Dusty are still unfused in Hadza: proximal calcaneum and humerus, proximal and distal femur and distal radius. All of the vertebral epiphyses of Hadza are unfused whereas those of Dusty are commencing to fuse. Taken at face value, this line of evidence would suggest that Dusty was the elder of the two. However, knowing that Hadza was castrated as an infant, Table 6: 1 demonstrates the delay in age of fusion as a result of this early castration.

In contrast the tooth wear stages, Table 6: 2, show substantially more advanced wear on the molar 3 of Hadza giving a higher MWS of 37 compared to MWS 34 for Dusty, though the wear stages on premolar 4 and molars 1 and 2 are comparable.

While both epiphysial fusion and tooth wear are inexact methods of estimating age at death, the example of Hadza and Dusty is of value for the interpretation of such lack of correspondence between the two methods. If this were an archaeological find, the first assumption would be that Hadza's teeth corresponded with Dusty's epiphyses and vice versa. One senior and one junior individual would be recognised, though a wider age gap than eight months might be postulated. This example does demonstrate the value of using epiphysial fusion as a check on the age range estimated from tooth wear. Where a discrepancy between the two methods is recognised, the presence of castrates in the assemblage might be proposed.

iii. Osteology and Pathology

iv. Skull and Mandibles

The posterior frontal with the horn cores, unfortunately, was left too long at too high a heat during processing, as it was not realised while the horn sheaths were *in situ* how porous the horn cores were. The horn cores are now crumbling and cannot be measured. This contrasts with Dusty whose horn cores are smooth and fully ossified and survived the preparation process intact. The prominent intercornual boss of the Jersey sire is absent. The skull is considerably larger than those of the Vycanny cows (Chapter 4) but the morphology and angle of attachment of the horn cores bear more similarity to the cows than to the horned skull of the bull Cyclone (Chapter 2). Hadza's skull could easily be confused with one from a large female. The occipital has yet to fuse to the parietal, whereas this is firmly fused on in Dusty with no visible fusion line. This delayed fusion of the occipital in conjunction with the wear on the teeth is the clearest indication that this skull derives from a castrate. Both mandibles exhibit OC depressions on the condylar process but not on the articulating temporal surfaces.

v. Ribs and Vertebrae

Two left and two right ribs display a notch and one right rib exhibits a foramen in the caudal border, discussed previously. One right rib has an exostosis with woven bone on the cranial border. This may indicate a fractured rib in the process of healing. One VC displays OC lesions on the cranial articular facets, while two VL have matching OC lesions on the articulating neural facets. Ten of the VT exhibit asymmetrical articular facets on the caudal aspect of the neural arch.

vi. Forelimb

There are slight depressions in the articular surfaces of the glenoid fossae on both scapulae, as though these were in the process of obliteration in life. The mid-shaft of the right ulna has a thickening, which is reflected in the ulna scar on the shaft of the radius. This anomaly is observed in archaeological finds and would appear to be a minor congenital trait. Both ulnae exhibit thickening of the margin of the semilunaris facet. Both distal radii exhibit minor OC depressions in the articular

surfaces. Like the scapulae, these appear to be in the process of disappearing and there are no corresponding lesions on the articulating carpals. Both proximal metacarpals have small OC depressions on the medial articular surface, with corresponding lesions on the articulating carpals 2+3.

vii. Hindlimb

The ilial-pubic border of the acetabulum in Hadza exhibits a stepped border showing an incipient notch. Despite the difference in age between Hadza and the castrates discussed in Chapter 3, Hadza does not show significant change in the morphology of this border, such as that described for the entire males in Chapter 2. Possibly such advanced morphological change may be a manifestation of the entire male rather than the castrate.

Both calcanea have woven bone on the lateral surface of the tuber calcanea. This does not appear to be a pathological response but rather the retention of a juvenile characteristic, indicating the bone was still actively growing at death. Both astragali have minor anomalies in the formation of the distal articular surfaces. Both tarsals 2+3 have anomalies in the proximal and distal articular surfaces. Those on the proximal surface are mirrored in the articulating facets of the calcanea and those on the distal surface with articulating facet of the proximal metatarsal. The right proximal metatarsal has the more severe lesions in the medial articular surface, in conjunction with lipping on the anterior border. The shafts of the metatarsals retain more of the juvenile woven bone character than the metacarpals, again suggesting that growth was still active at death.

viii. Phalanges

While in store awaiting cleaning, Hadza's feet became disarticulated during partial collapse of the shed, compounded by rat scavenging and gnawing damage. Consequently only five first and second phalanges and two third phalanges remain extant. The first and second phalanges are not matching pairs. Minor OC depressions are visible on the midline of all five proximal and three of the distal first phalanges but these appear to be in the process of disappearing. All five show varying degrees of extension of the distal medial articulation, with pronounced exostoses on one example together with lesions in the distal articular surface. The morphological changes appear to be more severe in the forelimb. Four of the five second phalanges have similar

lesions in the distal articulation, which appear to be fading in three examples. The two third phalanges display no anomalies. Although an incomplete set, the phalanges of Hadza serve as a cautionary example for the interpretation of similar lesions in archaeological assemblages, with examples ranging from normal to pronounced morphological change. The aetiology in this animal is clearly not associated with traction.

ix. Measurements

Since fusion has been delayed in Hadza, the suite of measurements that can be taken has the same restrictions discussed for the young stock in Chapter 3. However, Hadza is the last category of the herd to be considered so the distribution patterns for some aspects of the whole herd of reference skeletons can now be summarised. For the trochlea of the distal humerus, Figure 6: 1 places Hadza in relation to the adult bulls, the immature males and Dusty, the three year old heifer. It can be seen that the dimorphism between Dusty and Hadza is striking. Hadza is of similar size to Juglans Nigra, and together form an outlier to the main cluster, whereas Dusty and Cyclone are closer to the young males in size and proportion. For the astragalus, in Figure 6: 2, Dusty and Hadza are plotted against the young Dexter males, the two Dexter bulls and the Jersey crosses. All the Dexter males and Dusty form a cluster with Hadza as an outlier of the same relative proportions but larger than even Juglans Nigra. Two of the Jersey crosses are longer than the Dexters but of similar breadth while two are larger in both dimensions. It is clear that Hadza has bones that are proportionally more influenced by the Dexter dam than the Jersey sire. The difference in size and proportion in the Jersey crosses may be showing the difference between the Shorthorn and Angus sires. Certainly the common Jersey ancestry Hadza shared with these crosses is not apparent from the astragali. Figure 6: 3 compares the astragali of all the Dexter males and females with Hadza. Again, Hadza is a clear outlier at the top of the scale and as such might be interpreted as a bull if this were an archaeological sample. Separating the males from females from these data would be problematic. The extremes of the distribution would be recognised as female and male but the central spread of five females and five males would be difficult to interpret. The distal tibia in Figure 6: 4 shows a clearer separation of the sexes with Hadza, Juglans Nigra and Cyclone forming a small group at the upper end of the distribution. The distal tibia fuses at about 2-3 years of age, so Figure 6: 4 excludes the immature male Dexters,

whose astragali were included in Figure 6: 3. Withers heights, calculated from the greatest length of the metacarpal using Zalkin's average factor, are presented in Figure 6: 5. It can be seen that the two bulls are comparable in height to the females in the short and non-short ranges respectively. Hadza is an outlier at 1.3m, some 20cm taller than Juglans Nigra. Hadza had not attained his final height, dictated by fusion of all epiphysial ends. Plate 6: 11 shows Hadza standing next to Juglans Nigra, demonstrating the difference in height in life.

Bantu and Wellington were over 1.35m in height when 11 years old. Plate 6: 12 shows the shoulder height of Bantu in relation to the author and the cow Clarissa, while Plate 6: 13 shows the size of Bantu's head and the feminine morphology of the horns in comparison with Clarissa.

x. Discussion

The size difference between Hadza's bones compared to those of the adult Dexter cows and bulls is sufficiently great that if these were found in an archaeological context the immediate hypothesis would be that this individual did not belong to the same population. The term improvement might be invoked, with the implication of superior breeding. While Hadza was a cross-bred and therefore hybrid vigour might be cited as an explanation, Bantu and Wellington were pure-bred Dexters and, through living longer, attained a greater body size in life than Hadza. This profound difference in phenotype is solely the result of castration as an infant calf. This is one possible explanation for the appearance of larger, so-called improved, animals in 16th century assemblages. As noted above, Tusser suggested gelding January born bull calves at birth. The difference in size between the Vycanny cow who was the dam of Hadza and her offspring was of the order of magnitude seen in Plate 6: 5 and reflects Cobbett's (Cole & Cole 1930, 879-80) description of the early 19th century Welsh cows who were the dams of the massive oxen working in the fields of Kent and Sussex.

6.4 Archaeological Evidence and Case Studies

The fundamental importance of working oxen to the agrarian economy has stimulated much research to identify osteological characters that are indicative of

archaeological cattle bones deriving from draught oxen (Bartosiewicz *et al.* 1997; Cupere *et al.* 2000; Johannsen 2005; Groot 2005; Fabiš 2005; Telldahl 2005).

An assumption about the attributes of draught oxen bones, articulated by Johannsen (2005, 40), is that 'repeated abnormal strain on the body of an individual provokes a process of skeletal adaptation'. Various pathologies and abnormalities therefore have been interpreted as responses to the stresses placed upon the working animal. For example, Groot (2005) expanded on this concept by using the prevalence of osteoarthritis to identify possible draught oxen, and on finding that all the pelvic fragments in the assemblage under consideration were of female morphology, interpreted this as evidence for the use of cows as draught cattle. It has been shown in Chapters 4 and 5 that the Dexter cows exhibit similar pathologies without having been used as draught animals.

Taking into account the historical records, previously discussed, which suggest that oxen on large estates were consciously not over-worked and those on smaller holdings were not regularly worked, it could be proposed that the "null hypothesis" should be that well-cared for oxen ought not to exhibit skeletal changes. The case studies considered here have therefore been selected on the basis of sex ratio for the medieval draught example and metrical data for the post-medieval improved and fat oxen. However, the first case study examines a common approach to discussing beef from bones.

Case Study 1: Example of a "Commoditisation" Interpretation of Archaeological Data

Kron (2002) serves as an example of an interpretive approach that considers the production of beef to have been the primary concern of cattle herders in the western provinces of the Roman empire. The appearance of larger animals, under Roman administration, is taken to be an indicator of "improvement" in both feeding and breeding, with their subsequent disappearance part of the post-Roman descent into barbarism. However, Kron (2002, 12) does note that these larger animals may only be distinguished statistically and that some assemblages containing such bones are associated with sacrificial sites. The assumption is made that an increase in withers height equates to an "improvement in the yield of meat" (Kron 2002, 13). The data on which these comments are based are not presented but it is still possible to offer alternative hypotheses for the trends identified by Kron. The smaller cattle, with

a withers height of about 110cm, remained "in significant numbers throughout Europe through the Roman period, the Middle Ages, and beyond" (Kron 2002, 11), which suggests no fundamental changes in cattle keeping strategies. The larger animals, ranging from 120-140 cm withers height, need not be a separate breed, as postulated by Kron, but merely the upper end of the size range of the small cattle, possibly enhanced in size by early castration as shown by the examples above of the Dexter oxen.

As an example, Table 2: 2 shows the heights of 13 non-short Dexter bulls range from 112-132cm, with a mean of 118cm. To use a bull at the top of this size range and then castrate the larger male offspring as infant calves would effect the "improvement" discerned by Kron both rapidly and with minimal effort but without in any way creating a new breed or changing the fundamentals of husbandry. The motivation might be the requirement for a taller sacrificial offering, rather than more beef. The disappearance of the larger animals could be equally speedily effected by using only bulls at the shorter end of such a normal range of variation and castrating oxen as young adults. The response to changing market-led demand could therefore be met by simple manipulation of the bulls selected for breeding and age of castration, without invoking economic concepts unknown to the classical world.

Furthermore, height and weight of animal are not necessarily correlated: conformation may be more important than height. For example, weights of modern unimproved cattle breeds of broadly similar height, 110-120cm, but not build, can vary from about 300kg for an adult Chillingham bull to about 500kg for a non-short Dexter bull or Spanish *corrida* bull. In comparison, Kron (2002, 13) suggested 400kg at 130cm and 200kg at 110cm for archaeological steers. All these figures also ignore seasonal variations in the weight of the live animals (Duckham 1963, 275-277). It can be seen that simple assumptions of a correlation between height and meat yield are flawed, particularly in extending the modern concept of the commoditisation of cattle as beef into the past.

Case Study 2: Shapwick

Opportunities to test hypotheses on the diagnostic presence or absence of pathological conditions against unequivocal archaeological finds of oxen bones are rare. One possible example was encountered during the excavations at Shapwick in Somerset (Gerrard & Aston 2007, 425), where a feature filled with articulated

skeletons, predominantly of cattle, was uncovered, Plates 6: 14a-b. Though this burial deposit was not fully excavated, parts of a minimum of seven cattle bodies were recovered from the half section, which revealed the underlying structure of the lime kiln. The fill containing the skeletons was removed in arbitrary 10cm spits, disregarding articular connections between adjacent bones and resulting in recovery damage to the bones. An exercise in conjoining broken fragments of the pelves showed that joining fragments of individual bones were recovered from all three spits, indicating that deposition of the bodies was a single event with no archaeological stratigraphy corresponding to the arbitrary spits.

In the absence of any archaeological finds other than animal bones, the feature was dated by C14 samples of two tibiae from distinct individual cattle, which produced a calendar C14 date range of AD 980-1160. On statistical grounds, it is most likely that the cattle died in the first half of the 11th century, AD 1000-1050 (Gerrard & Aston 2007, 425).

The Domesday record for Shapwick indicates that the demesne farm had four ploughs (Costen *et al*. 2007, 26-31). The later records for another manor of Glastonbury Abbey, Podimore, indicate that the team for each plough comprised eight oxen (Fox 1986, 533). The surviving demesne accounts for Shapwick (Ecclestone pers. comm.) for 21 years between 1258 and 1334 indicate an average of 49 manorial oxen present at the Michaelmas accounting, with a range of 23-66. No female cattle are recorded and only 3 calves over two separate years and 22 bullocks over three separate years. This later documentary evidence therefore suggests that the principal manorial cattle maintained at Shapwick were oxen, in the sense of castrated males used primarily for ploughing arable.

It was therefore anticipated that the majority of the cattle buried in this feature could derive from such oxen. Extrapolating the number of bodies represented to include the unexcavated half of the pit suggests that the equivalent of two plough teams of eight oxen could have been buried here. Whatever the catastrophic cause of death, both murrain (epidemic disease) and starvation (hypothermia in extreme winter weather) are possibilities (Gidney, forthcoming a & b), the contents of this burial pit represent a snapshot in time of the composition of the live cattle herd in 11th or 12th century Shapwick, in contrast to the deliberate culling of fat, unthrifty and aged stock that comprise the bulk of most commonly encountered medieval archaeological

assemblages of cattle bones from towns, castles and the like, deriving from food and hide processing and domestic consumption refuse.

The disused lime kiln that the carcases were deposited in was close to the *curia*, or manorial administrative centre of Shapwick. The use of the lime kiln for disposal of the corpses suggests that the bodies were tainted beyond any possibility of salvage, lime is still used as an agricultural disinfectant and lime was interleaved between the bodies (Gerrard & Aston 2007, 425). The absence of any skinning, butchery or gnawing marks on any of the bones found also suggests rapid disposal with no salvage or scavenging. The proximity to the *curia* suggests official disposal of manorial property, similar to the advice given in didactic treatises of the 13th century, whereby fallen stock were inspected by the manorial officials to ascertain the cause of death (Oschinsky 1971, 423).

Although whole carcases had been deposited in the pit, the nature of the excavation resulted in the collection of loose rather than articulated bones. Analysis had to be of the assemblage, rather than the individuals (Gidney 2007b, 899-903).

It was clear that one small adult cow, with an estimated withers height of 0.94m, was represented, Table 6: 3. The pelves had fragmented during excavation, so it was not possible to use these to estimate the sex ratio during the original analysis. Subsequently many fragments have been re-assembled, resulting in examples from the small cow alluded to and four males, using the criteria of West (1990 for 1988) for the pubes and Grigson (1982, 8) for the ilial-pubic border. A further two incomplete examples were comparable with the other males. None of the reconstructed pelves form matching pairs from individual cattle. This sex ratio from the pelves complemented the initial suggestion that most of the bodies were male and therefore possibly oxen.

Table 6: 3 shows the range of withers heights, estimated from the metapodials using the average of the factors for cows and steers given by Zalkin (Driesch and Boessneck 1974, 336).The small cow at 0.94m is quite distinct from the remaining metapodials, with an estimated height range of 1.06-1.15m, and one slightly taller example at 1.18m. Similarly, six of the eight distal metacarpals in Table 6: 3 fall within a distal breadth range of 56.7-59.3mm. No clear matching pairs of metapodials were observed during recording, and only two tentative pairs of metacarpals may be suggested from these metrical data. These measurements do suggest that the cattle

buried in this feature were sufficiently similar in height and foot breadth that the deposition of matching yoke pairs of oxen is a possibility.

The age at death of the cattle burials was considered from the tooth wear stages, which form a tight group in Figure 6: 6 spanning MWS 37-46. There is a striking absence of the younger animals represented in the food debris from other excavations at Shapwick, conversely few jaws from this range of MWS were recovered from the other Shapwick sites (Gidney 2007b, 901).

As noted above, Hadza aged 3 years 8 months was at MWS 37, and in Chapter 5 it was observed that 8-9 year old Dexters were at MWS 43-44, with Dexters at MWS 45 aged over 10 years.

Using these data, together with the advice given in the historical texts discussed above, it is possible to speculate that these Shapwick cattle might equate to animals aged from three to in excess of ten years. Such an age sequence of animals could represent oxen broken to the yoke at about three years old, to replace oxen culled from ten years old. It is improbable that entire male cattle in this age range would have been retained without a large proportion of females, for which there is neither archaeological nor historical evidence at Shapwick.

The age of the cattle was then considered from the fusion of the epiphyses. The limb bones in Table 6: 4 include a high proportion of unfused elements among those that fuse by four years of age, following Silver (1969), which suggested that the heads appeared to derive from older animals than the legs. The hypothesis proposed was that the bodies might be of castrates, hence a delay in the fusion of the later fusing skeletal elements compared to the stages of tooth wear (Gidney 2007b, 902). The example of Hadza illustrates the effect of castration in delaying fusion relative to the age indicated from tooth wear. Other possibilities were acknowledged, for example that the diet of the cattle may have been such as to increase the rate of attrition of the teeth relative to the stages of epiphysial fusion. However, the converse, that a low plane of nutrition could have inhibited long bone fusion relative tooth wear, was not explicitly considered. The occurrence of winters so severe as to warrant mention in the Anglo-Saxon Chronicle in AD 1042, 1046, 1115 and 1116 (Ingram 1929, 123-190) suggest that cold and hunger over winter may well have impacted on the growth rates of young cattle in the time period spanned by the C14 dates from the bones.

Given the putative identification of the Shapwick cattle bodies as primarily representing oxen, comparisons were sought with other modern and archaeological specimens to confirm the hypothesis. A diligent search for exostoses on the proximal third phalanges, suggested by Johannsen (2005, 40-41) as a reliable indicator of draught exploitation, was made on all the third phalanges recovered but no example was found. The Shapwick cattle may have died before they were old enough for this exostosis to have had time to develop. Alternatively, this feature may not be a reliable indicator of the draught ox. As noted for Juglans Nigra in Chapter 2 and Kirstie in Chapter 4, an age-related aetiology is more probable in the Dexters.

Asymmetrical cattle vertebrae have been discussed by Fabiš (2005, 58-62) in relation to possible draught exploitation. No evidence for any vertebral abnormalities was observed among the Shapwick cattle bones, though examples are discussed for the Dexter bulls in Chapter 2 and the young males in Chapter 3.

Pathological conditions of increasing severity, such as those described for the Juglans Nigra in Chapter 2, are associated with the feet of modern culled draught oxen (Bartosiewicz *et al.* 1997). None of these changes were present in the Shapwick cattle, or in a 6 year old modern ox in Bartosiewicz's study, suggesting that working cattle in their prime would not yet have developed these morphological responses.

None of the male acetabula from the Shapwick cattle exhibit the eburnation suggested by Groot (2005) as evidence for the use of cows as draught cattle. Such eburnation in cows has been discussed in Chapters 4 and 5 and is not related to draught work by the Dexters.

This total absence of pathological changes in the Shapwick cattle skeletons negates assumptions of any simple correlation between use for draught work and morphological changes to the skeleton. Rather, this absence of distinctive pathologies implies that the advice given in the treatises, recommending regular culling of old and weak oxen and those with bad teeth, was practiced at Shapwick. Furthermore, Langdon (1986, 268) suggests that the eight ox teams of demesne farms were not created for ploughing efficiency but to conserve the strength and well-being of animals worked over very long ploughing seasons. This is another reason why the oxen belonging to a manor, rather than those of the tenants performing customary labour, might not be expected to develop signatures on the skeleton indicative of draught work.

The purchasers of these old cull oxen, other than the grazier and butcher, are not mentioned specifically but there was possibly a market for some of them. The manorial tenants, whose livestock are not detailed in demesne records, may have bought animals that they were accustomed to working with. Bartosiewicz *et al.* (1997, 120) discuss bonding between oxen and their handlers. These tenants would have different financial incentives to the accountants of the manor, whose concern was that the lord's capital invested in the demesne herd should not depreciate and therefore recommended rolling programmes of replacement. The purchaser of elderly oxen would more probably want the animals to live sufficiently long to minimise the annual depreciation of the initial outlay, ending with the animal being culled without 'owing anything'. It is these oxen that might be anticipated to develop pathological changes, in association with advancing age. Another scenario for an increase in age and work related arthropathies would be the aftermath of a population crash, such as that which befell the Shapwick cattle. Despite the wide-ranging inter-manorial exchange systems and purchasing power of Glastonbury Abbey, a regional or national cattle mortality of the scale seen at Shapwick would increase the value of surviving animals. These would have to be kept beyond their normal working lifespan until replacement stock could be bred up.

While data from modern draught oxen are invaluable, the Shapwick find demonstrates that extrapolation of such data onto archaeological specimens from a different country and landscape is problematic. No contemporary oxen are ploughing the equivalent of the medieval open fields, on good low-lying agricultural land. The modern Rumanian oxen studied by Bartosiewicz (*et al*. 1997, 15-18) were sourced from hilly areas, up to 700m altitude, and several had been used for heavy logging. No modern estate manager is regularly dealing with the purchase and transfer of many head of draught oxen between the demesnes of a number of manors to maximise the return on the capital invested in the animals and minimise potential loss. The Shapwick example may demonstrate that such large scale operations, cashing in culls for beef before any depreciation in value, would not keep working oxen with any of the skeletal defects frequently interpreted as evidence for the presence of draught oxen.

Case Study 3: Dorchester

A 17th or 18th century pit excavated in Dorchester produced an assemblage solely containing intact bones of the feet: metapodials and phalanges (Davis 1987b). The analysis sought to understand the reason for deposition and to ascertain the proportions of males, females and castrates present from metrical analyses. While metacarpals are the most readily recognised sexually dimorphic skeletal element, Davis found that, despite using a range of standard metrical indices, it was in fact difficult to interpret the sex ratio of the sample. Few of the foot bones exhibited exostoses, interpreted as the result of excessive strain, so the speculative interpretation was that all the feet derived from retired milk-cows and that the bones represent waste from a cow-hide tannery. More tangible evidence was derived for the size of the cattle, which were certainly larger than 16th century and later cattle bones from Prudhoe castle in Northumberland but overlap with the 16th century range from Baynard's Castle in London. Davis (1987b, 8) postulated that this size difference reflected both the improvement of cattle in post-medieval England and the appearance of large breeds earlier in southern England than the north. As noted in Chapter 2, subsequent work by Albarella and Davis (1996 for 1994, 42-57) identified the appearance of larger cattle at Launceston castle, Cornwall, in 15th-17th century deposits, and suggested a change in genotype related to the importation of Dutch cattle. Rixson (2000, 183-5) also gives a useful summary of some of the historical evidence for increase in size of earlier post-medieval cattle, again linking this to the importation of Dutch cattle. The widespread historical influence of Dutch breeding on British dairy cattle is illustrated by the genetic link between the Ayrshire and Friesian breeds in animals with no recent introgression (Wiener *et al* 2004, 600). The extinct Sheeted Somerset breed of dairy cattle were believed to be the result of such crossing between Dutch and local cattle (Hall & Clutton-Brock 1989, 72). The Dorchester cattle bones may represent archaeological evidence for such animals.

In trying to establish the sex ratio of the Dorchester assemblage, one analysis that Davis did not consider was a plot of the estimated withers heights of these cattle from the metacarpal measurements. Figure 6: 7 presents these data, using the same average factor of Zalkin previously discussed (Chapter 4). While the range of heights spans 1.16-1.48m, the majority cluster between 1.24-1.32m with a smaller cluster at 1.36-1.4m. Hadza, standing at 1.3m, falls in the middle of this range. The Dorchester cattle were far taller than the Romano-British and medieval cattle discussed in

Chapter 5. The group in the range 1.24-1.32m correspond approximately in height to the modern Jersey cow, the smaller of the commercial dairy breeds. However, the taller animals could indicate the presence of castrates, particularly the tallest animal at 1.48m. An alternative explanation might be that these feet bones do not represent one "breed" but an admixture of imported and cross-bred animals. This hypothesis would suggest that the smaller number of taller animals might represent the imports and the less tall but larger grouping the cross-breds, with the single example at 1.16m being the uncrossed native type. Such an interpretation was not considered by Davis but would support the suggestion made that all the cattle were female. Conversely, the example of Hadza could suggest that the phenotype had been manipulated by early castration and that steers bred for beef rather than traction may be represented.

Case Study 4: St Giles by Brompton Bridge

During rescue excavation at St Giles by Brompton Bridge, North Yorkshire, five complete cattle burials dated to the early or mid 18th century were located and excavated (Stallibrass 1993). The nature of the burials and the dating suggested that these cattle were victims of one of the pandemics of rinderpest recorded for 1709-20, 1742-60 and 1768-86 (Broad 1984, 104). Details of the 18th century requirements for disposal of such carcases are given by Rixson (2000, 371-5). These archaeological finds appear to corroborate that the sick animals were killed at a place distant from other kine and buried at least 4 feet deep.

Stallibrass (1993) considered the ageing information from epiphysial fusion and tooth eruption and wear and suggested that individual No.1 (BSG1) was aged between 3 and 4 years at death and individual No. 4 (BSG4) was slightly older. Since Hadza falls within this age range, the tooth wear for BSG1 and BSG4 are compared with that for Hadza and Dusty, in Table 6: 5.

It can be seen that BSG1 has more advanced wear on P4-M2 than Hadza but less wear on M3, giving a MWS score one point higher than Hadza. The stage of epiphysial fusion in Table 6: 6 is more comparable to the younger female Dusty than the older steer Hadza. There is not the discrepancy between tooth wear and fusion seen for Hadza and the Shapwick skeletons, suggesting that BSG1 is not a castrate. Despite this, the withers height estimated from the metacarpals is 1.46m, at the top end of the range established for Dorchester. The tooth wear and epiphysial fusion for BSG4 are in agreement that this is an older animal. Standing at about 1.38m, BSG4

also falls within the range of the smaller group of taller animals from Dorchester. BSG4 is very close to the estimated height of 1.37-1.41m seen for the Shorthorn bull Comet in Chapter 2 and in Figure 6: 8.

Davis (1987b, 8) points out that improved Shorthorn cattle, associated with north-east England, were not introduced into Dorset until c. 1870. The similarity in height between the taller Dorchester and the St Giles cattle may reflect a common Dutch ancestry. Dutch cattle were imported to the east coast and were used in the creation of the large Teeswater and improved Shorthorn cattle. These imports triggered the 18th century outbreaks of rinderpest.

What is clear from the Dorchester and St Giles cattle is that "improved" animals in the 18th century sense are represented, beyond the size range of even the early castrate Dexter as a proxy for the indigenous small cattle. The very largest animals represented approach the height range of the aurochs cow, discussed in Chapter 2, reinforcing the suggestion made there that the aurochs size range is the genetic default and the very small cattle represent active breeding policies to maintain diminution.

Case Studies 5 and 6: Masham and Alnwick

Both Masham and Alnwick produced finds almost exclusively of metapodials from large cattle. Those from Masham were found during the watching brief of a service pipeline in Masham market place (Stokes and Huntley 1998). Like the metapodials from Ripon market place, discussed in Chapter 4, all the Masham bones had been broken mid shaft and no intact bones were found from which withers heights could be estimated. The finds from Alnwick (Archaeological Services 2006) were comparable to those from Dorchester, being deposited intact in a discrete pit. Both deposits are dated by association to the 18th or early 19th centuries, in the absence of artefacts. Clearly two processes are leading to the deposition of these assemblages of metapodials. The broken bones from Ripon and Masham indicate use of the marrow, probably for neat's foot oil. The reason for the deposition of intact bones at Dorchester and Alnwick remains less obvious to explain, other than an assumption of hide processing. Both the Masham and Alnwick reports are assessments of potential with recommendations for further work, which has never materialised. Limited metrical data are therefore available.

Only Greatest Length measurements were taken of the Alnwick metapodials for assessment, with a full metrical record recommended. Figure 6: 8 compares the heights estimated from the Dorchester and Alnwick metacarpals with Hadza, St Giles and Comet. It is clear that even at the late date of the Alnwick finds, there are very small cattle still present which are absent from Dorchester. Only two of the Alnwick bones and Hadza fall within the main peak of the Dorchester distribution. Over half of the Alnwick bones, together with those from St Giles and Comet, fall at the top end of the height range established from the Dorchester bones.

Interpretation is still not clear but one possibility for the Alnwick assemblage is that the height range 1-1.18m could represent unimproved cows. Using the example of Hadza, those at 1.3-1.32m could be early castrate steers bred from the small cows or, by comparison with Dorchester, cows of improved type. The range 1.36-1.46m could indicate males of the improved cattle as the known Shorthorn bull, Comet, falls in the middle of this group, together with BSG4. The very largest bones in the range 1.46-1.48m from Alnwick, Dorchester and BSG1 could, from the example of Hadza, represent castrates of the improved type. Whatever the true explanation, clearly there were some radically divergent phenotypes in the cattle supplied to Alnwick, suggesting a husbandry regime contrasting with Dorchester. The smallest of the Alnwick cattle could represent dairy cows of the type immortalised by the sculpture of the Dun Cow, discussed in Chapter 4, whereas the peak in the Dorchester distribution could represent dairy cows of improved type. Compared to Dorchester, rather more of the beef purveyed to Alnwick would appear to have derived from males of improved type, possibly physical evidence for the breeding policies of the Culley brothers (Orde 2004). The size differential shown in Plate 6:10 would have been seen in the shambles of Alnwick.

Since the Masham bones are broken and no measurements were taken of the proximal or distal breadths of the Alnwick bones, Figures 6: 9 and 6: 10 compare the proximal and distal breadths of the metacarpals from Dorchester and Masham. The proximal ends show a normal bell curve distribution for the Dorchester sample, with the Masham sample mostly falling within it but with more larger and some smaller bones from Masham. Hadza falls well in the mid-range. The Shorthorn bull Comet extends the upper end of the range, demonstrating the very robust build of the improved Shorthorn sire.

The greater robustness of the Masham bones is more clearly seen in the distal ends, with five examples falling well beyond the Dorchester range. Hadza and the remaining Masham bones fall in the upper half of the Dorchester range but it can be seen that the majority of the Dorchester bones are much narrower. Both bulls and castrates have broader feet than females, so this distribution suggests that a large proportion of the Dorchester sample may be female. Comet falls at the top of the Dorchester range but below the top of the Masham range, further suggesting that these particularly large and robust bones represent steers.

In summary therefore, the Masham sample would appear to contain physical evidence for improved cattle of heavy and robust build, either the Teeswater or Shorthorn type. The example of Hadza, and by proxy Bantu and Wellington, demonstrate how difficult it is to separate phenotype and genotype from earlier appearances of larger cattle bones. Where only metapodials are recovered, there can be no check between tooth wear and rates of fusion to suggest the presence of early castrates. The post-medieval changeover from the ox as a working animal, needing the late castrate's bull-like neck to power the yoke, to the ox raised as a beef animal needed to fatten as rapidly as possible, needing the early castrate's ongoing growth, should be visible in the archaeological record. In practice, as Davis (1987b) concluded, the data remain ambiguous. However, the value of the early Shorthorn bull, Comet, in demonstrating where a known male lies on the scale has helped confirm Davis' suggestion that most of the Dorchester cattle were probably female. Conversely, Comet indicates that the larger Alnwick and Masham cattle may have been males of comparable build but castrates.

6.5 Discussion

The concept of a stratified livestock industry is well understood today, with small, hardy hill-bred cattle supplying lower lying enterprises with stock to fatten. Cobbett's description of the small Welsh cows breeding the steers that grew into the massive draught oxen of southern England (Cole & Cole 1930, 879-80) is a practical illustration of this system. The bones of the Vycanny cows in Chapter 4 and Hadza demonstrate how this difference might appear archaeologically. Such a scenario is

rarely considered in discussions of archaeological assemblages, though it is an obvious explanation for some of the observed size variation.

Discussion of improvement, in the sense of larger bones, is generally taken to be one line of evidence to suggest the influence of an occupying power, such as the Roman Empire, though Sykes (2007, 52) failed to find any concrete evidence for Norman influence on English cattle. The explanation for this may lie in the attitude of the medieval elite, who expended their energies in this direction in breeding horses, and the fact that the ploughman did not breed the oxen himself. Chapters 3 and 4 have highlighted the role of women in calf rearing and cow management. It is at this grassroots level that decisions would have been made on the breeding strategy to produce the male calves to rear, even if the subsequent decisions on castration and training were made by the ox-herd. The "crumpled" horns depicted on medieval oxen reinforce the fact that this was a favoured point to select for in the milch cow. For manors, such as Shapwick, where cows were not normally maintained on the demesne, cattle-breeding would appear to have been in the hands of the tenants. In contrast to home-bred beasts, the importation of cattle from abroad would have been in the hands of men, particularly when sea-borne attacks merely extended the normal range of the cattle raid. The post-medieval creation of the fat ox in part reflects the changing role and exclusion of women from practical involvement in breeding strategies.

Since the examination in Chapters 2-5 of the incidence of pathologies recorded as present in known draught oxen has shown that these are endemic within the population of Dexter reference skeletons, no attempt has been made to pursue the correlation of such anomalies with oxen further. Instead the examples of Hadza and the Shapwick skeletons indicate that inconsistencies between tooth wear and epiphysial fusion may be a more fruitful line of enquiry to pursue, particularly for the recognition of early castrates.

The simple equation of arthropathies with draught oxen also fails to take cognisance of the fact that there would always have been two tiers of oxen. Those belonging to large estates, whether Roman villas or medieval manors, would have been the equivalent of the high specification modern tractor: bought new, expensive, well looked after but replaced with a newer model at regular intervals to maintain reliability and work load. Those belonging to the tenants may have been more akin to the grey Ferguson: bought cheaply second-hand, useful on smaller holdings with

lighter work, cheap to run with minimal maintenance but liable to wear and tear failure with increasing age. Only oxen in the latter scenario might be expected to develop chronic arthropathies, but whether debilitating conditions would be tolerated in an ox, which could be cashed in for beef to pay for a replacement, is another matter.

Chapter 7. The Herd: Discussion

Chapters 2-6 considered the individual constituent members of the reference herd of Dexter cattle in the context of a range of historical source material and as applied to selected archaeological exempla. Here, a brief synopsis of themes identified in the preceding chapters will be considered together in an endeavour to comprehend archaeological herd management strategies.

7.1 The Dexter Reference Collection

The first point to be made is that, while the Dexter skeletons are a real death assemblage, the composition of this herd lacks members that would be anticipated in archaeological assemblages. Specifically, there are no adult males castrated at 2-3 years old and subsequently used as draught oxen and no females aged 4-7 years. While there is good representation of immature males, the majority do not appear in the metrical analyses as the relevant epiphyses are unfused. Establishing the sex ratio in an archaeological assemblage is crucial to interpretations of milch cow versus draught oxen strategies but it was seen in Chapter 6 that even large collections of archaeological metacarpals, the most sexually dimorphic bone, can be ambiguous to interpret.

The Dexter cattle reference skeletons have proved to be an invaluable resource. The aetiology of skeletal anomalies found on archaeological specimens has been put into the context of animals of known life history, allowing re-consideration of the archaeological examples. The Dexters demonstrate the wide range of phenotype present within a population with a restricted genetic base. This size range mirrors that found archaeologically, leading to the proposition that much of the fluctuation in size seen in archaeological assemblages could represent sub-sets of the same population within a stratified system: large castrate oxen on arable lowlands having been bred from small upland vaccary cows. The impacts of castration and dwarfism on the extremes of the size range were considered. Rather than dismissing the dwarfism inherent in the Dexter as an anomaly irrelevant to archaeological comparison, it was suggested that some of the smallest archaeological female cattle must be expressing a form of dwarfism. This proposition should be able to be tested by future aDNA

studies. The examples of skeletons from carrier and non-carrier Dexter cows of comparable height demonstrate the problems of visually or metrically recognising carriers among fragmented archaeological bones. The metrical data from the Dexters demonstrated that in any of the temporally, and to a lesser extent geographically, diverse archaeological samples discussed, at least some of the Dexters fell within the same parameters. The metrical data from the calves indicated that formulae to calculate age of gestation derived from modern breeds were giving inaccurate results for Dexter-sized archaeological specimens, leading to a reconsideration of calf mortality patterns.

7.2 Archaeological Comparanda

i. Metrical Data

Sykes and Symmons (2007, 520-522) demonstrated the value of known sex modern reference material for establishing the dividing line between males and females on a scatterplot of basal cattle horn core measurements. It was shown that in a blind test, 10 zooarchaeologists failed to correctly identify the separation line between the known sex examples. The Dexter reference collection is therefore of value in extending the range of known sex metrical data for comparison with archaeological finds, and Chapter 5 used these data in support of interpretations of female cattle at sites such as Grimes Graves.

Chapter 2 defined the suite of measurements that were taken on the Dexter bones as being on robust elements that survive in the archaeological record in sufficient numbers for analysis to be attempted. The astragalus is one element where metrical data are available for the whole range of juvenile, adult and cross-bred reference skeletons. However, Chapter 3 demonstrated the problems inherent in the interpretation of such data, where breeding and feeding are unknown variables. The distal trochlea of the humerus should display sexual dimorphism between the robust forequarter of the bull and the gracile forequarter of the cow, as seen for the short-leg Dexters in Figure 4: 5b and the non-short Dexters in Figure 5: 5a. The effects of early and late castration and use for draught on the morphology of this bone do not appear to have been studied to date. The distal humerus is the only fused measurable bone present for most of the younger male Dexter specimens, so giving a dataset that

encompasses all the size, age and sex variables in the reference herd for comparison with an archaeological assemblage.

Legge (2008, 539-40) used the measurements of this element to suggest the sex ratio of the Neolithic cattle slaughtered at Hambledon Hill, Dorset, though pointig out the inherent problems of an early age of fusion and continuing growth post fusion. Legge suggested that a plot solely of BT showed a bias towards smaller animals, putative domestic cows, while the fewer but larger specimens were suggested to include domestic males and possibly aurochs. The Hambledon Hill measurements, excluding estimated values, are plotted against the Dexters in Figure 7: 1, where it can be seen that though some Dexters are smaller than the Neolithic cattle, there is considerable overlap, and similarity in the underlying pattern of size distribution with a peak of smaller, and tail of larger, measurements. Figure 7: 2 subdivides the Dexters into males, both entire and castrate, and females and there is a suggestion that rather more of the Neolithic cattle could be small, younger, males than proposed by Legge. To clarify this proposition, the Dexter data were moved up the scale in Figures 7: 3 and 7: 4 so that the smallest specimens matched the smallest Neolithic examples. It can be seen that the range is now a good match for that of the Dexters, with the largest examples equivalent to the Dexter adult non-short bull and adult steer. Since the steer, Hadza, was 7 years younger than Bantu and Wellington, discussed in Chapter 6, for whom no bones are extant but who had certainly grown beyond Hadza's dimensions, an alternative interpretation of this comparison is that the largest Neolithic examples represent domestic males rather than aurochs. It can be seen that while Legge's suggestion that the smaller bones indicate females may be correct, Legge failed to suggest that a significant proportion of these smaller bones may also derive from younger males, despite highlighting the potential problems of using this early fusing element. Certainly BT 78 as the upper limit for the Neolithic cows can be seen to err on the generous side, BT 74 would appear to be closer to the overlap between females and younger males from the Dexter analogy. Legge proposed that a scatterplot gave a better indication of two groups within the distribution. Figure 7: 5 plots the Hambledon Hill data, less the estimated values, against the Dexters. The line indicates approximately the point, HT (LT) 48, above which Legge interpreted the aurochs distribution to lie. Since some of the modern, younger Dexter males approach this, and the senior Dexter males fall within this proposed aurochs distribution, it would appear that Legge's interpretation may be flawed.

The application of a null hypothesis of an equal sex ratio to the Hambledon Hill data would reduce the separation point between males and females to BT 72 on Figure 7: 2, representing 25 female bones and 24 male bones from animals of a range of ages and possibly including castrates. This model has not been tested but was not considered by Legge.

There is no direct association of humeri with mandibular teeth, so it cannot be proven which size range belongs with which age class proposed from the teeth. Unlike the metrical data, the tooth wear data are not presented in detail by Legge. Despite this, it is possible to counter-propose that the mandibles assigned to the younger groups aged up to 36 months could include a higher proportion of males than suggested by Legge, with more of the females in the 3-8 year groups.

The post-glacial climatic optimum may well have led to a reduction in the body mass of the aurochs, discussed in Chapter 2, but not even the relic post-medieval population is believed to have been reduced to the size range of the modern Dexter, as would be the case if Legge's interpretation of the Hambledon Hill data were accepted uncritically. This is an example where "know-how" informs "knowledge". Since the size parameters of the live animals in the Dexter reference collection can be visualised by the author, the scatterplot can be immediately "read" and the aurochs interpretation seen as untenable. The size difference between the humeri of an aurochs and Juglans Nigra, the non-short Dexter bull, was demonstrated in Plate 2:16c. Figure 7: 5b adds the Hawick aurochs and the improved Shorthorn bull Comet to the Dexter and Hambledon Hill datasets. Both lie far beyond the range of the Dexters and Neolithic cattle. In Figure 7: 5c, Mesolithic aurochs are plotted against Hambledon Hill and a further Neolithic assemblage from Rudston Wold (Rowley-Conwy and Owen 2011), confirming the size contrast between the domestic cattle and the aurochs. However, comparison with Figure 7: 5b shows that, in these dimensions, Comet falls close to the Star Carr aurochs range. This partly confirms the suggestion, made throughout, that an increase in cattle size may be due to a relaxation of active selection for small phenotype, allowing reversion to the aurochs size range.

The distal humerus is not an element that would normally be considered by the author for determination of the sex ratios in an assemblage. Such use of metrical data by prehistorians was considered to confirm O'Connor's (2003, 73-3) proposition that economic strategies suggested by prehistorians are not relevant to the social and economic structures of medieval England.

Following on from Sykes and Symmons (2007) blind test, Figure 7: 6, showing the scatterplot of Dexter distal humerus dimensions, was sent to a range of specialists requesting interpretation of the sex ratio of males, females and castrates. Responses were received from university staff, freelance, commercial archaeological unit and museum specialists, with respondents from Iceland, France and Spain as well as Britain. A cross-section of current practice was therefore obtained.

No-one considered this to be a viable exercise on a real archaeological assemblage. Three respondents refused to attempt the separation. One considered there was no visible separation other than the two largest examples. One wrote in detail that on complex sites receiving beef on the hoof and on the hook from a variety of landraces with unknown planes of nutrition and timing of castration, together with the early fusion and continuing growth of this bone, the range of variables precluded any such interpretation. Furthermore, the whole concept of using metrical data to attempt interpretation of the sex ratio was considered to be increasingly dubious in the light of Sykes and Symmons (2007) example. One respondent took another view of the dataset and while declining to annotate the graph, was intrigued by the wide range from a known breed sample and therefore applied log ratio analysis, using the Ullerslev aurochs cow as the standard and comparing the result with two Neolithic assemblages in Table 7: 1.

Table 7: 1 Log Ratio results received in lieu of annotated graph

Aurochs	min	-0.09	difference	0.22
	max	0.13		
Hambledon	min	-0.16	difference	0.17
Hill	Max	0.01		
Eton	Min	-0.21	difference	0.28
Rowing Lake	Max	0.07		
Dexters	Min	-0.15635	difference	0.130078
	Max	-0.02627		

The result apparently compares well with the single species aurochs and the Hambledon Hill Neolithic assemblage (Gill Jones pers. comm.). In terms of the Dexters, this is of great interest as the short and non-short phenotypes do not appear to affect the overall integrity of the population for such comparisons.

Several responses suggested the metacarpal as the only element worth using to attempt metrical separation of the sexes. These respondents assumed that all the reference specimens were complete skeletons, whereas most of the young males considered in Chapter 3 were dressed carcases with no heads or feet. A situation that would be commonplace in archaeological assemblages from complex sites.

Figures 7: 7a-h show the range of graph annotations received. There was a broad consensus that the smallest bones were female and the largest male. Castrates were mostly assumed to fall somewhere in the midrange, apart from two suggestions of the largest bones as castrates. No-one researched the breed to find out about the dwarfism and two phenotypes. No-one considered that in a modern British cattle population most of the males would have been beefed at younger ages than the cows and the impact this might have on bone size and development.

Figures 7: 8a-b are the key to Figure 7: 6. The sex ratio is equal, if castrates are counted as males, but it is clear that the male distribution has broader parameters than the female. It is unlikely that any zooarchaeologist could accurately identify from Figure 7: 6 the presence of normal and dwarf cattle, females, castrate and entire males, immature and adult males, yet this is the sum of the parameters of the population. The results of this straw poll of the profession and the complexity of the key to Figure 7: 6 suggest that Legge (2008) was being optimistic in the interpretation of the distal humerus metrical data from Hambledon Hill, particularly under-estimating the possible range and proportion of younger males present.

Given the potential ceremonial and stock exchange activities on Hambledon Hill, the younger males could represent animals brought for selection and redistribution for reproduction and the fate of failed contenders in some of the bull sports to establish breeding rights, discussed in Chapter 2. The very largest male animals might represent both bulls and possibly the Neolithic equivalent of the exhibition oxen, discussed in Chapter 6, and their ceremonial dispatch and consumption. What Legge also failed to discuss in the Neolithic data in Figure 7: 5 is the small clusters of overlapping points at the lower end of the range. The overlapping points at the bottom of the Dexter range represent the Vycanny cows, discussed in

Chapter 4, and therefore could suggest that the Neolithic examples might also represent related herd members. It can be seen that the association of the information from source materials discussed throughout this project, with the data from the Dexter reference collection have provided analogies to suggest alternative interpretations of the cattle remains found at Hambledon Hill.

ii. Dwarf Cattle

Figure 7: 6 also demonstrates the lack of visibility, and hence archaeological cognisance, of the presence of dwarf cattle from measurements where no complete bones are extant. One of the themes explored throughout has been the evidence, or lack of it, for the presence of either dwarf cattle in antiquity or normal cattle of Dexter dwarf size. In Chapter 4, it was proposed that dwarf cattle have an advantage in milk productivity for forage input compared to their normal sisters, particularly in marginal and montane pastures. The suggestion was made that no dwarf males would be reared so descent of dwarfism could only be through the female line, thus avoiding homozygous breeding of the recessive. However, Figures 7: 1 and 7: 2 demonstrate that incomplete bones of males expressing this dwarfism might not be readily recognised. Since no researchers are actively looking for evidence of the Dexter dwarfism, or related variants, there are no explicitly comparable data. The small stature of later prehistoric and Romano-British cattle was considered in Chapter 5 as a starting point for consideration of the proposition of the presence of such dwarfism in archaeological populations.

Figure 7: 5c shows one female Mesolithic aurochs falling within the parameters of the Neolithic domestic cattle. Comparison with Figures 7: 8a-b shows that this small aurochs cow falls within the immature Dexter male range, with BT comparable with Cassie, discussed in Chapter 5 as a large dwarf-carrier. The fact that a wild Mesolithic aurochs cow lies in the mid-range of the Dexter distribution is astonishing, but attracted no comment from Rowley-Conwy and Owen (2011). Such an animal is an obvious possibility as both a dwarf-carrier and the type of foundation female selected for domestication.

iii. Dairy Conformation

Chapters 4 and 5 equated gracile build with selection for dairy character in cows. By way of recapitulation, Figure 7: 9 compares measurements of the distal humerus trochlea from the Bronze Age Grimes Graves cattle with the Dexters. It can be seen how very gracile in build these prehistoric cattle were compared to the Dexters, although the withers heights in Figure 5: 8a indicated that the Grimes Graves cattle were mostly taller than the modern Dexter cows. This is one aspect of the Grimes Graves assemblage that was not emphasised by Legge (1992, 27) in his consideration of the number of cattle generations, from the First Neolithic to the Middle Bronze Age, in which human selection pressures had been brought to bear. The very conformation of these cows indicates a preference for dairy build.

iv. Size Variation

Rather than dwarf cattle, most commentators appear more concerned with establishing evidence for larger or "improved" animals. Throughout, it has been proposed that simplistic equations of bigger with better and smaller with retrograde were legacies of 18th century and later economic and eugenic theories, particularly the commoditisation of beef for large urban markets, inappropriate for application to earlier periods. Instead it was proposed in Chapter 6 that stratified farming systems with small upland dairy cattle supplying steers for lowland draught and beef might be a more appropriate hypothesis. Similarly, increases in size in black rats in the post-medieval Little Ice Age and decreases in size in 21st century Soay sheep on Hirta were taken to show that changes in the size of cattle could reflect pragmatic responses to environmental determinism, rather than preconceived breeding plans.

Instead of seeing the advent, with domestication, of diminutive cattle as a retrograde step, the impact of the reduction in size on sexual maturity was seen as a positive in Chapter 2. Comparison with modern data suggested that this would have decreased the generational interval, speeding up the process of human selection for particular traits. Whether such selection was intentional or an inadvertent side effect of culling out policies remains moot.

The concept of the "best" animals having a shorter life expectancy was seen in Chapter 2 as a paradox confronted by herders selecting for longevity and a possible reason for dedicating the "best" animals as sacrificial offerings.

v. Cattle Sports

Evidence has been presented for a range of sporting uses of cattle, including cows in Chapter 5 and steers in Chapter 6, as well as the better known bull fights in Chapter 2. Such sports can be a communal selection process for the stock bull, training for new ox-teams or selection of a feisty herd matriarch to control the herd on summer hill grazing. The popularity of such sporting gatherings is not generally considered as a function of large monuments with no permanent occupation, such the Hambledon Hill Causeway Camp, above. The losers in such sporting events may be represented by the cattle bones recovered.

It was suggested that in monetised economies, such sports could influence the breeding of appropriate animals, whose conformation and temperament might differ from standard zooarchaeological expectations for milk, draught and meat. Despite the enhanced monetary value of such animals, this is a selection pressure not normally considered by zooarchaeologists.

vi. Hunting

While the author's area of expertise lies in the later Iron Age to Early Modern timescale, speculative excursions were made into earlier prehistory to consider the impact of selective hunting on aurochs bulls in Chapter 2 and the biology of cattle for management of the cow and calf and dairy exploitation in Chapters 3 and 4. It was proposed that selective hunting of senior adult breeding bulls could have changed the dynamic of the herd structure. This hypothesis has been substantiated by the work of Fisher on reasons for the extinction of the mastodon (2009 and Daily Telegraph 5/5/13). It appears that selective human hunting of the biggest and most dominant mastodon males led to increased hierarchical battles between younger males, in which female and infant mastodons were collateral casualties. The long-term impact of continually removing senior breeding males led to extinction, despite the relatively low numbers of animals killed.

The contemporary herd structure of the Chillingham cattle gives an indication of the possible herd structure of the aurochs and the impact of increased aggression between younger males within the female herd, if the restraining influence of the King Bull was removed. Since the 20th century, no males have been either castrated or culled, therefore the equal sex ratio in the calves born is maintained in the adults. Of the 100-120 head, only 20-30 are proven breeding cows, not all of whom rear a calf

every year (Hall 2012, 14-15). It can be seen that accidental fatal injury to infant heifer calves during combat between younger males would soon impact on the sustainability of a comparable herd of aurochsen.

Human disruption of the herd structure in the aurochs was followed by domestication, with extinction only in the 17th century. It was proposed that while selective hunting may have wrought such devastation on the male aurochs, observation of the biology and behaviour of the breeding females and young aurochsen may have been applied to create a sustainable exploitation strategy. This could have been achieved by increasing the proportion of breeding cows within the wild herds by the simple expedient of selectively culling male calves. By reducing the number of male aurochsen, the prestige value of hunting senior males would be enhanced and overall male aggression levels reduced.

vii. Calf Slaughter and Milking

The Mesolithic hunted calves at Ulkestrup Lyng, the domestic cattle at Grimes Graves, the medieval didactic treatises and observation in modern cattle, discussed in Chapter 3, all show exploitation of the change in behaviour commencing when the calf is about 50 days old. The bond between cow and calf weakens, with the calves forming nursery groups, in the charge of one adult, between bouts of suckling. Such calves can be vulnerable to predation in the wild or killed for veal in domestic herds. It was suggested that such manipulation of wild herds by extracting senior and infant males could have created herd structures comparable to those seen in domestic herds where milk is a primary management strategy.

Medieval depictions of milking scenes were compared with the didactic treatises to suggest that the calf shown in such milking scenes was destined for slaughter at about this 50 day old threshold. Like infanticide in humans, calf slaughter can be seen as the optimum method of controlling herd size in relation to labour and management inputs for dairy work, herding and over-wintering. This would be understood by women in particular. A collateral effect would be to enhance the return to oestrus and breeding interval of the dam.

No historical evidence was found for preferential slaughter of bull calves and rearing of heifer calves. Rather both sexes appear to have been of equal financial value and reared in equal proportions. Instead, it was found that traditionally all the first calves from heifers were killed and all calves born in the spring. Despite such a

cull appearing counter-intuitive, evidence was presented for the increased survivability of calves born later in the year. Factors allowing the development of such aseasonal breeding in domestic cattle compared to the rut and seasonal breeding of the aurochs were discussed in Chapter 3.

In medieval deposits, the presence of mandibles from very young calves and very old adult cattle was seen as supporting evidence for a dairy strategy. The longevity of cattle, with tooth wear stages in advance of those recorded for the known age Dexters, led to speculation on the life span of cows, in particular, and the possible nature of human-cattle relationships in Chapters 4 and 5.

viii. Pathology

A range of congenital and pathological changes were recorded on the bones of the Dexter reference skeletons in Chapters 2-6. Osteochondrosis in archaeological cattle bones has recently attracted attention. Suggestions were proposed for the possible aetiology of the condition in the Dexters, particularly the younger males in Chapter 3, related to ambient temperature and plane of nutrition at the stage of epiphysial ossification. Sex-linkage of osteochondrosis in males and occipital and vertebral perforations in females was considered as a topic for further study. A suite of arthropathies have become accepted as zooarchaeological indicators of the use of cattle for draught work. The entire range is represented in the Dexter reference collection, with one cow skeleton having the full set, despite none of these cattle having been yoked. It was therefore proposed in chapters 2 and 4-6 that such arthropathies are not reliable indicators of draught oxen. Instead the presence of such arthropathies on the hind limb bones of known dairy cows suggests one possible differential diagnosis, related to the udder of the high-yielding dairy cow.

ix. Identification of Oxen

Historical information in Chapter 6 suggested that large arable estates would have a management and culling policy designed to minimise wear and tear on working oxen. Therefore, rather than using arthropathies to identify such oxen, it was proposed that a contrast between ages estimated from epiphysial fusion and tooth wear would indicate the presence of castrate males. Males castrated at c. 6 months old were shown to subsequently exhibit differences in skeletal development compared to entires (Shahin *et al* 1992). No comparable recent data were found by the author for

males castrated at 2-3 years old, as suggested by the historical sources, since in modern studies male non-breeding cattle are beefed by this age. The adult steer, Hadza, was shown to have delayed fusion relative to tooth wear. This was also seen in the bodies recovered from the Shapwick burial pit, leading to the suggestion that these animals had been manorial oxen, despite the absence of arthropathies.

x. Eating Quality of Meat

Since archaeological cattle bones represent consumption of meat, whether beef or veal, the eating quality of meat relative to age and sex of animal was discussed in Chapters 3, 5 and 6. Legge (1992, 25) articulates a standard zooarchaeological approach to meat quality: that effective meat weight is reached in males aged about 2 years, as the rapid phase of juvenile growth slows as the animal approaches adult size and the carcase gives the best return of meat for feed inputs. Tellingly, Legge also mentions that this is the basis of modern production methods. Such approaches were examined in detail and shown to be largely fallacious historically, prior to the 18th century. Instead known methods of curing and cooking meat in the past were examined and, in conjunction with experience of the meat quality of the reference Dexters, hypotheses indicating a preference for mature cow beef were proposed. In support, an example was given of modern cash values for cull cow beef being in excess of those realised for prime male beef. The contrast in preferred meats appears to have been between dark, well-flavoured cow beef suitable for slow, moist methods of cooking and white, tender, 2 month old veal suitable for broiling, nowadays grilling, or frying as "collops", now escalopes, and as spit-roasting joints.

xi. Women and Cattle

This study has exposed some shortcomings in understanding cattle management, particularly the role of women. Woolgar (2006, 96) noted the traditional link between women and dairying and evidence in support of this contention was presented in Chapter 4. Discussions of the fluctuations in size of archaeological cattle fail to consider that women may have been the driving force in the selection of size and build of cattle in dairy-based management systems and that women may have different views of attributes, such as size, compared to men. The productivity of the small, high-yielding dairy conformation cow tends to be ignored by male commentators interested in beef as a commodity. Even Legge's (1992) interpretation

of a dairy based strategy at Grimes Graves failed to consider the potential return from dairy produce compared to the cull strategy and meat represented by the bones.

Chapter 8: Conclusions

The challenge posed by this project was a dispassionate survey of evidence from historical, literary, artistic, husbandry and veterinary sources to establish new and nuanced interpretations of cattle exploitation strategies from archaeological evidence. Complementing these desktop surveys has been the data from the author's reference collection of, principally, Dexter cattle skeletons of known age, sex and life history and the experience of managing a live herd of Dexter cattle. When combined, these have enabled an authoritative approach to speculative questions raised by archaeological finds, particularly on the aetiology of certain pathologies. Sadly, few, perhaps no other, practitioners currently working in Britain have the knowledge of animal husbandry and archaeological practice required to bring such a project to fruition, and perhaps this is the single most important conclusion from this research: a practical understanding of animals on the hoof and on the hook has a rich contribution to make to archaeological interpretation of faunal remains and must be tapped if the marginalisation of cattle and their keepers is not to continue.

At the conclusion of this project, various new themes suggest themselves for the future:

- This study has been based on a wide range of archaeological sites across Britain. Emphasis has been placed on the ways in which resources differed between parts of the countryside and future studies could aim to nuance its conclusions through a comparison between regions. European data might be introduced by way of contrast with other climates and seasonalities, agrarian traditions and faiths. The need for social and historical context has been stressed and should not be ignored in any zooarchaeological study, although it is still topography and soil types that tend to be used as explanation for differences in husbandry methods.

- In order to examine the individual constituents of the whole herd and the interplay between age and sex groups in husbandry and management, the theoretical basis for this thesis was grounded in a new approach, now commonplace in many spheres of archaeology. This is the concept of the 'biography' or the Operational Chain and the epistemology of craftsmanship,

particularly the relationship between unconscious and intuitive "know-how" and communicative "knowledge". These are themes which could now be extended to the study of other domestic animals.

- The implication of primary decision-making by women in dairy-based cattle management strategies requires further exploration and might be extended to other aspects of, for example, medieval household economies. The practicalities of vaccaries in the uplands have hitherto attracted less attention than the male-dominated arable cultivation around lowland settlements (Dyer 2002). On the wild and barbarous fringes of medieval England, where cattle-raiding was a way of life, it has been proposed that the milking cows functioned as a mobile field kitchen, staffed by dairy maids. This model, and the associated feasting on stolen cows, was considered as a potentially more appropriate interpretation of cattle bones from earlier archaeological sites. The utility and productivity of such small hill cattle was suggested by analogy with the dairy Dexter cows in the reference collection and herd milk records.

- Among the themes which require more detailed analysis in an archaeological context is 'folklore'. In this thesis we have seen how examples of supposed superstition with regard to both live cattle and beef cookery have been validated when tested scientifically or practically. Rather than dismissing folklore wholesale (van Vuure 2005), it was proposed that such folklore embodies "knowledge" for transmission. A project to draw together this information with an archaeological eye would be a useful and stimulating interpretative tool.

By way of a more general conclusion, three points might be highlighted. First, there are many benefits to be shared from connecting animals and things with the people who cared for them and one of the outcomes of this research has been a better understanding of the processes through which people and animals have become intertwined. Second, the influence of late 18th century economic thinking, leading to the commoditisation of cattle, an equation of bigger with better regardless of input costs and the application of the principles of eugenics to breeding, strongly permeates zooarchaeological thinking. These concepts are wholly inappropriate for pre-

industrial sites. Instead of "improvement", the word needed to inform interpretations of cattle keeping strategies is "profit". It is the margin between inputs, such as fodder, and overheads, such as buildings, with the outputs from dairy produce, veal calves and cull cows that is of importance, not the size of the animals. Such balances between inputs and outputs are the key to understanding non-monetised as well as cash-based economies and they are the basis for traditional low input – low output strategies. Once this is understood, the small cattle can be shown to be consistently more profitable whereas large cattle are vulnerable to fluctuations in demand. In spite of statements to the contrary, the bones from small cattle from archaeological sites spanning millennia do indicate continuing profitability. The quest for "improvement" can therefore be abandoned. Instead, nuanced interpretations of standard analyses, such as age at death patterns and occurrence of congenital abnormalities, can be used to infer the "know-how" of husbandry, "transforming intuitive, esoteric knowledge into an acknowledged form of reasoning" (Bender Jørgensen 2005, 68). Finally, the language of "improvement" is deeply unhelpful when it comes to understanding the wide range of uses to which cattle were put, even in the recent past. To take one topic, animal sports have barely been assessed from an archaeological perspective. In another case, prior to the 18th century, no evidence was found for the concept of herds of cows single suckling calves to be reared for beef. At the very least, this calls into question the 20th century concept of dairy produce as a "Secondary Products Revolution" subsequent to men herding suckler cows as an alternative to hunting. Instead, women milking cows and cattle as pack and riding animals were proposed as alternative scenarios. This is just one illustration of the need to broaden our understanding of cattle and their uses in the past.

Appendix 1: 1 Review of Historical Sources Cited

Historical (Lucas 1989), classical (Jameson 1988, 93) and ethnographic (Dahl & Hjort 1976) sources indicating that cattle were both units of value and stores of wealth, of higher status than, for example, sheep or goats. The very word cattle derives its meaning from 'capital' in the sense of chief property or chattel (Epstein and Mason 1984, 6). Cattle were therefore of central importance to the economy of many societies in the past, beyond the basic produce of the dairy and of meat and hides. For example, Sykes (2007, 29) summarises the evidence which indicates the cultural importance of cattle in Viking society, even where environmental conditions were not conducive to cattle husbandry, such as Iceland.

The value of cattle as indicators of status in excess of simple economic worth is reflected in traditional literature, the most notable example being the Irish *Tain Bo Cuailnge* (Kinsella trans. 1969). This epic story depicts an entire country being plunged into warfare over the ownership of one bull. While this may be heroic fiction, the ethos of the cattle raid as an exhibition of manly prowess permeates the historical literature of Ireland (Lucas 1989) and is mirrored in Wales (Griffiths 1994, 69) and the Anglo-Scottish border (MacDonald Fraser 1974) throughout the medieval and into the post-medieval period. The propensity of the Celtic peoples of Britain to engage in cattle raiding remained as a cultural stereotype in 19th century literature. Examples include *Namgay Doola and the heifer's tail* (Kipling 1987, 213) for the Irish, the *War Song of Dinas Vawr* by Peacock (ed. Brimley Johnson 1906, 341-2) for the Welsh and the popularisation of the 16th century Scottish *Border Ballads* by Scott (1931).

Law Codes, Chronicles and Husbandry manuals

For Britain, there are three main groups of medieval and post-medieval texts, widely referred to by zooarchaeologists and agricultural historians (Albarella 1999). Firstly, there are the Welsh *Laws of Howel Dda*, written down in the 12th century from an oral tradition some 250 years older (Wade-Evans 1909). These reflect a society where cattle-raiding was not a crime but an honourable activity of a noble household. Contemporary entries in the *Anglo-Saxon Chronicle* (Ingram 1929) suggest this ethos was also integral to pre-Norman lowland England. Cattle-raiding was only exterminated by the English in Scotland (McHardy 2004) and Ireland (Lucas 1989), with difficulty, in the 18th century.

Fussell (1972) discusses the survival of classical agricultural texts and their influence on later farming manuals. The prime text of the medieval period is the late 13th century text known as Walter of Henley. Oschinsky (1971) has produced the definitive discussion of this work, together with the relevant parts of the contemporary accountancy texts *Seneschaucie* and *Fleta*, and Robert Grosseteste's *Rules*. An earlier discussion of the same group of texts by Cripps-Day (1931) still has merit as this was written from the viewpoint of a practical farmer during a period of agricultural depression, rather than an academic interested in the finer points of textual criticism. Cripps-Day (1931) emphasises how the basic tenets of Walter resonate down the ages and can still be pertinent to small-scale traditional holdings some 600 years later. This in part explains the enduring popularity of Walter of Henley's advice after the advent of the printing press, despite major changes in manorial farming and the associated audits.

Thomas Tusser, by his own biography (Hartley 1969, 13-21), was a younger son of a gentleman, born in Essex, educated at a chorister school followed by Eton and Cambridge. He then spent ten years as a courtier before taking a wife and retiring to East Anglia to earn a living farming. Tusser's 100, then expanded to 500, Points of Good Husbandry, originally published in several editions between 1571-1580, are written in verse and are original compositions, not re-workings of classical authors and Walter. Despite being dismissed as "doggerel" from a literary viewpoint, Tusser was a highly educated man, trained in music, and understood the necessity of metre. Tusser's verses may not be high literature but they are easy to recite and memorise and are full of useful, practical advice. Tusser may be seen as a forerunner of the recent phenomenon of educated highflyers leaving the urban rat race for a rural idyll, then finding that writing a book about their experiences is the only way to fund their new lifestyle. Such new entrants to agriculture frequently encounter a steep learning curve which can be, as Tusser found, financially crippling. Such literature remains popular, Moffat (2004) achieving sales in the top ten of non-fiction titles. Tusser's work is therefore invaluable as the advice that a literate new entrant to farming found of personal value and wished to disseminate. The present work is this author's contribution to this literary genre. It cannot be emphasised too strongly that such works are aimed at the peer group of the author. At no period in time are such books usually composed by, or for, those who are born into agriculture and learn the practicalities first hand from a tender age. Cobbett (1850 facs., 96-7) articulates this

very clearly: "whatever the cares created by the cow …. is amply compensated for by the education that these cares will give to the children. They will all learn to milk, and the girls to make butter. And, which is a thing of the very first importance, they will all learn, from their infancy, to set a just value upon dumb animals, and will grow up in the habit of treating them with gentleness and feeding them with care. To those who have not been brought up in the midst of rural affairs, it is hardly possible to give an adequate idea of the importance of this part of education."

Gervase Markham (Best 1986) writing, rather later than Tusser, into the 17th century, was also a scion of impoverished gentry. Markham endeavoured to generate income from his writing as much as from his farming, to the extent that he was forced to sign a memorandum promising not to write any more books on the diseases of livestock. Markham describes himself on this document as a gentleman of London (Best 1986, xiv). While Markham's works were mostly published in the early 17th century, Best (1986 xvi-xxii) makes it clear that the content includes material of widely varying origin and antiquity. This is in contrast to Tusser, whose work is all original composition from his own experience.

Arthur Young (1771) follows Tusser's format of a monthly calendar of work but is of particular interest as a snapshot of ideal practice and new crops and planting regimes during the boom period of the "Agricultural Revolution", before depression set in.

All of these authors were educated gentlemen. Markham and Young, particularly, earned more of their income from writing than from farming. The advice they give is an ideal, which may have been honoured more in the breach than the observance. Nevertheless, it is of value to know what the ideal was in order to extrapolate from the archaeological finds, where possible, how far reality departed from the ideal.

Cobbett is the exception to these gentlemen authors, having started life as a ploughboy before becoming active in politics in later life. Cobbett's politics and writing (1819, 1830) were driven by the contemporary, post-Napoleonic, agricultural depression and its effect on the rural poor.

Artistic Representations

The artistic representations contemporary with archaeological finds of animal bones provide an opportunity to put flesh on the dry bones and endeavour to interpret human attitudes towards the livestock of the time. Hartley and Elliot's (1931, 4) exposition on the utility of such images remains valid. Andersson (2010, 4) details the problems inherent in using medieval art as a source for medieval dress but concludes that, with a source critical approach and knowledge of the themes and conventions of medieval art, such images can be used as a source for the study of clothing.

A wealth of medieval illustrations of cattle have survived, for example the adoption of the ox as the symbol of St Luke and the presence of the ox in the nativity tableau means there are religious images spanning several centuries from all over western Europe, giving indications of the implicit symbolism employed by the artist to convey information to the viewer. Books of Hours and Psalters are rich sources of illuminations of the Labours of the Months, annual calendars of agricultural tasks involving cattle, both ploughing and dairying. Perez-Higuera (1998) illustrates a chronological sequence of examples of these medieval calendars but only one of these was produced for the English market, the Bedford Hours dated c. 1425. The outstanding English example of the depiction of rural labour is the Luttrell Psalter, discussed by Backhouse (2000) and Brown (2006a). Henisch (1995) discusses the contemporary place of these rural images and their use in modern interpretations of medieval agriculture. Basing (1990) gives a very useful synthesis of pictorial and literary sources for agriculture and husbandry. Medieval Bestiaries are also a fruitful source of images. Barber (1999) is a good example of a facsimile Bestiary, retaining the original size and layout but with the text in modern English, and also containing a commentary on the purpose of these books.

Though these works are a fantastic resource, the modern commentaries often show a lack of practical understanding of the agricultural tasks depicted. Basing (1990, 15) suggests that the depiction of ploughing as a January labour of the month in early 11th century English calendars shows the influence of southern European models rather than contemporary practice. This interpretation ignores the fact that spring sown cereals and fallow fields remained the norm in medieval and early modern England and therefore ploughing commenced at the end of the Christmas festivities. By the 15th century, this had become formalised as "Plough Monday", the first Monday after Twelfth Night (Hutton 1996, 124). At a practical level, Rider

Haggard (1899, 48-99) gives a detailed account of ploughing in Norfolk with horse teams from the 6th January 1898, on heavy clay land. Basing (1990, 16) further suggests that it is unlikely that a patron of lavish and expensive illustrated books "would have been pleased if the miniatures in his fine, new manuscript had shown dirty, ragged peasants". A close perusal of the Labours of the Months in the *Très Riches Heures du Duc de Berry* (Longnon & Cazelles 1989, 2-13), the most magnificent of this genre, clearly shows ragged hose on the March ploughman and October sower. The shepherds visited by the Christmas angels also have ragged hose and decrepit boots (Longnon & Cazelles 1989, 44). This is as it should be, re-affirming the social hierarchy with the rich man in his castle and the poor man at the gate. The poor men's labours are explicitly creating the wealth of the rich man. Basing (1990, 16) sees white hose as impractical wear on ploughed fields, without appreciating that these indicate linen hose, readily laundered, or that a field ready for sowing will not, by its very nature, be muddy. For example, Rider Haggard (1899, 124) observes that a seed bed ready to drill was abandoned for the day after a sharp storm made the land too sticky.

Brown's discussion of the Luttrell Psalter demonstrates a lack of familiarity with contemporary costume. Sir Geoffrey's "distinctive headgear" (Brown 2006a, 17) is remarked upon without any comment indicating understanding that this represents the start of the transformation of the liripipe hood into the chaperon hat. The waiting man at table is described as "wearing an exotic, eastern-style striped scarf reminiscent of a Jewish prayer shawl" (Brown 2006a, 42) without any recognition that this is a standard arming towel, denoting the function that day of the wearer (Brears 2003, 77). A similar lack of understanding is shown for the harvest scene, where Brown (2006a, 48) describes the sickles in use as scythes and makes a gratuitous interpretation of the tie with which the man is about to bind the sheaf as "a curious corn dolly resembling a phallus", possibly demonstrating more insight into the 21st than the 14th centuries. Sheaves of corn are described as bales and the cartload of sheaves as hay (Brown 2006a, 53). Of more interest and importance would be accurate identification of the cereal crop being harvested. It is clearly bearded and Backhouse (2000, 23) therefore assumed it represents barley. Neither Brown nor Backhouse considered the possibility of a bearded wheat. The ears are not shown hanging down as in a ripe barley crop but standing erect, like wheat. It is certainly not bread wheat. However the upright ears and dark awns, explicitly painted by the artist, indicate that this is most probably rivet

wheat (*Triticum turgidum*), known from archaeobotanical evidence to have been introduced after the Norman Conquest (Sykes 2007, 37) and cultivated in medieval Lincolnshire (Charlotte O'Brien pers. comm.). Successful wheat harvests, as the basic cash crop, would have enhanced the wealth of Sir Geoffrey and paid for the creation of the ambitious Psalter. The Luttrell Psalter could be seen as a classic example of investing agricultural profit in a conspicuous display of wealth, rather than ploughing such profit back into the land.

None of the art historians appear to consider such basic aspects of these iconic images, and the statements being made to contemporary viewers of these illuminations. These examples of lack of appreciation of such details render other academic interpretations of rural labour in these works as of questionable value. The countryman, whether landlord or tenant, would have no difficulty in identifying and empathising with these agricultural scenes, as many tasks remained unchanged into the 20th century.

Even eminent commentators on medieval art, such as Camille, sometimes miss allusions in imagery. In the discussion of the coitus of creatures, Camille conspicuously failed to recognise that the only marginal image depicts a jack donkey, identified by his dark coat, long ears and cross on his shoulders, covering a pony mare (Camille 1992, 46-48). This act of miscegenation, necessary for the procreation of a mule, illustrates Camille's thesis of the manuscript margin as a site for 'joke-work'. "Unless the joke is shared and we 'get it', it fails" (Camille 1992, 43). In this instance, Camille himself has failed to 'get' the joke, that the jack donkey is cocking a snook at the lawful pairings illustrated in the main body of the text. The joke can still work as this author was amused by the image before reading the associated commentary and analysis. Camille's suspect natural history is further demonstrated by discussion of a "bright red toy-like elephant" (Camille 1992, 48) in an illumination (Camille 1992, 51) which clearly shows a bright red boar and a bright red bull but an uncoloured outline drawing of an elephant.

Given such failings of academic interpretation of rural imagery, the following chapters will discuss some commonly reproduced images of this genre, principally in relation to the management of the live animal and husbandry treatises.

Appendix 2: 1 Bull Sports

The natural selection combat between senior males to establish breeding rights and the religious associations of the entire male have spawned a range of bull sports over the millennia. Once such sports became part of a monetary economy, such as the Roman amphitheatre, there would have been a financial incentive to breed appropriate animals. Bull sports may be divided into broad kinds but there is considerable overlap between activities and all aspects are preserved within the Iberian and southern French bull fighting tradition. Recurrent themes are apparent throughout the spatial and temporal distribution of these sports. The sporting bull is not a scenario which is normally considered in the interpretation of bone assemblages. The presence of non-breeding adult entire males could obscure evidence for the breeding stock bull. Modern concepts of economic productivity from faunal remains (O'Connor 2000, 91) generally fail to consider working uses of cattle beyond milking cows, draught oxen and the stock bull. This section will present some of the diversity of evidence for the sporting use of the live bull, which may suggest possibilities for future interpretations of archaeological data.

The simplest form of bloodless bull fighting consists of pitting two evenly matched bulls against each other. This activity is of considerable antiquity, being depicted in Egyptian tombs of the Upper and Middle Old Kingdom (Tyldesley 2007, 40). The contestants are separated once one has been defeated. The venue can range from totally *ad hoc* to a grandstand. Whitlock (1977, 86) illustrates an example from India, Plate 2:4 is a postcard from Thailand and a scan of world wide web resources produces similar examples in the Balkans, Oman, Kenya, China and Korea. This would appear to have evolved from farmers using the wild principle of the King Bull either defeating, or being defeated by, a challenger in the selection of breeding stock. Such a struggle, as the author can testify, is immensely exciting at close quarters. Superficially the Kenyan example (www.kenyasafari-direct.com/activity/bull-fighting-events-in-kakamega) appears to be an unambiguous member of this group. However, this "age-old tradition" appears to date back merely to the end of the Second World War, though it is actively promoted by the Ministry of Tourism to Westerners and, like the Roman arena, is used by politicians to bolster their support base. In fact, most modern bull sports appear to be of surprisingly recent origin. A

successful fighting bull is worth a considerable amount of money in a poor society, irrespective of its ability to breed.

Other bloodless sports involve an acrobatic display or trial of strength between human contenders and the bull, but both parties may survive the public encounter. The bull may be subsequently sacrificed or slaughtered afterwards but outside the arena and not as part of the public performance.

The most famous example of the acrobatic sport is depicted in the Minoan wall paintings from the palace of Knossos, Crete. These have been extensively re-interpreted by Bietak *et al* (2007) in the light of the more recent discovery of contemporary Minoan wall paintings from an Egyptian palatial complex at Avaris in the Nile delta. This acrobatic sport involved several participants with different roles, some of whom vaulted or somersaulted over the head of the bull and some of whom wrestled the bull (Bietak *et al* 2007, 84). This was not a risk free spectacle for the human participants (Bietak *et al* 2007, 85) and one of the scenes from Avaris shows a bull collapsed from exhaustion (Bietak *et al* 2007, 64). It is suggested that the bull may then have been sacrificed (Bietak *et al* 2007, 128) but this is not depicted. The whole spectacle is clearly associated with Minoan royalty and has religious connotations too. This iconography is not exclusive to Minoan culture, Bietak *et al* (2007, 130-2) discuss the Syrian evidence and conclude that the bull sport was part of the affirmation of the divine right of kings. Bietak *et al* (2007, 83, 127-8) convincingly refute the original interpretation that the white skinned participants were women. Since white skin in these wall paintings is normally shown as a female attribute, indoor workers in contrast to the brown skinned men who work outdoors, these white skinned men may represent the social elite who were not involved in outdoor manual labour. This is an important point as all bull sports can now be seen to have only men as active participants. Similar acrobatic displays by *recortadores* still form part of both the Iberian repertoire and French *courses landaises,* and support Bietak's (2007, 115) contention that Arthur Evans' reconstruction of Minoan bull leaping should be re-evaluated. A further variant of the acrobatic encounter with the bull is the pole vaulter, or *salteadores* (Whitlock 1977, 88). This sport is of considerable antiquity being known in the Roman world, depicted for example on Roman oil lamps, as shown in the reproduction in Plate 2: 4.

Bull wrestling continues today, particularly as an aspect of the modern Portuguese bull fight. In the simplest version, found in the Azores, the bull is attached

to a long rope held by six men. An area is roughly barricaded and the bull introduced for the assembled young men to taunt into charging, who then attempt to run out of the bull's reach. Many are not swift enough and get tossed. The bull's horns are either padded or have artificial blunt ends attached, to reduce the damage inflicted. The six men on the end of the rope haul the bull off the fallen man. In the more formal arena sport, the bull is tired first by the aristocratic mounted *cavaleiros*, who plant darts on his shoulders. Then the lower class *forcados*, a team of eight men with no protection or weapon, tackle the bull. The lead man provokes the bull to charge and attempts to secure the bull's head while the rest of the team endeavour to immobilise the animal. Bietak *et al* (2007, 55) note the similarity between the horn grip used by the white skinned participants in the wall paintings with the posture of the lead man of the *forcados*. In the Portuguese bull fight, the bull leaves the ring alive and is slaughtered out of sight of the spectators. The Portuguese community in California took their tradition of bullfighting with them. It was officially outlawed in 1957 but has since been permitted *in connection with religious ceremonies and festivals* (author's emphasis), with certain changes made to conform to animal welfare legislation (New York Times online 27/6/01).

The famous Pamplona bull run is only one aspect of the bull sports associated with the festival of San Fermin, originally held in the autumn, harvest home time, but now moved to cater for the summer tourist trade. Variants of the Mediterranean bull runs involve the young men attempting to collect a token secured between the bull's horns. Jallikattu in South India is a similar bloodless sport, associated with a religious festival and agricultural fertility. Here, the bulls are decked in garlands and have a cash bounty in a cloth bag secured between the horns, which the men then endeavour to wrest off. Bull running survived in Britain into the 18th century (Whitlock 1977, 65-6).

The modern successor to the bloodless bull sports in Britain are the cattle classes at agricultural shows, Plate 2: 6. These continue to be hotly contested, and the author has indulged in this activity, despite a range of modern techniques to quantify elite breeding stock from parameters other than visual inspection. The cowboy culture of North America developed further bloodless bull sports very recently, including bull riding, which now form part of the contests integral to a rodeo. It can be seen that bloodless bull sports are an ongoing and vibrant tradition that is constantly mutating. Superficial similarities between events separated in time and

space may merely represent parallel developments rather than continuity. It can be seen that the breeding and use of bulls primarily for sporting purposes is not confined to social class or religious persuasion but is actively pursued wherever cattle are bred and active young men abound. This has implications both for the prevalence of bones from bulls that might be expected in archaeological assemblages and the type of animal deemed desirable. Such concepts are rarely actively considered in zooarchaeological interpretations.

In the blood sports, the death of the bull is predestined as part of the spectacle but the human contenders may also be injured. The simplest form of bull bloodsport is the hunt, hence the preservation of the last living population of aurochsen in the Polish Royal Forests (van Vuure 2005, 65-7). Van Vuure (2005, 90) cites Caesar's description of the kudos young Germanic men could obtain by killing aurochs because of the danger involved. The 15th century aurochs hunter, illustrated by van Vuure (2005, 90) appears to have been a single armoured knight on horseback armed with a sword. According to the 14th century Hunting Book of Gaston Phebus (d'Anthenaise 2002, 62), dispatching quarry with a sword was considered more noble. The aurochs was already so rare that even Phebus' comprehensive study of game and how to kill it does not include the aurochs. The classic Iberian bull fight may have arisen as a substitute for the aurochs hunt. Whitlock (1977, 64) describes early bull fighting as the mounted knight tilting against the charging bull, as in a joust, and that this practice was still current among cattle raising country gentry as a bloodless sport. A similar pastime for the nobility might be inferred from the references to *tauri sylvestres* in English medieval forests (Harting 1880, 221). The public bull fight, spearing the bull from horseback, remained the prerogative of the gentry until the early 18th century, when the king forbade it as too many of the nobility were getting killed or seriously injured. The lower classes then took over the sport and the modern Spanish bullfight has since evolved into its present stylised form, which is a considerably less equal contest between men and bull.

The Spanish bull fight has spawned a whole industry breeding bulls for the prime purpose of a 15 minute contest in the arena. The cattle, such as those in the Camargue studied by Schloeth (1961), are run in range conditions that allow the expression of natural behaviour patterns. Selection of breeding stock is based on temperament that would be considered undesirable in most domestic cattle. Size is important as the bull must not be so tall that the matador cannot stand on tip toes to

deliver the killing downward blow, Whitlock (1977, 85-6) estimates an average of four feet high, or 1.22m, well within the range of Dexter bulls available on A.I. in Australia noted earlier. Although skeletally such relatively small bulls might appear "unimproved", one outstanding sire of fighting bulls, Alcalde Plate 2: 7, is so valuable that $50,000 were spent in an attempt to clone him (International Herald Tribune on line 5/3/08, 23/3/08). The economic return of smaller archaeological cattle may therefore not necessarily be directly related to beef and dairy yield.

Although of comparatively recent origin, the modern bull fighting arenas do evoke the Roman amphitheatre, which certainly included bulls among the attractions. For example, a mosaic from Thysdrus depicts five resting bulls while their carousing human adversaries are admonished "silentium dormiant tauri – silence, let the bulls sleep" (Wells 1992, cover illustration). The comparison is particularly marked at Arles, where the Roman amphitheatre is still used for staging bull fights, Plate 2: 8. In a province like Britain, where the aurochs was already extinct, it is eminently possible that some entrepreneurs could have seen a niche market to supply bulls for such entertainment. Among the livestock raising scenarios envisaged by zooarchaeologists, that of such a specialist bull enterprise tends to be conspicuous by its absence. In urban Romano-British assemblages, for example, such an aspect of the assemblage might be expected to skew the age and sex distribution from that expected for a market receiving cull dairy cows and plough oxen for beef. It is unlikely that the damage inflicted to the bull's shoulders by the picadors, bandilleros and sword of the modern Spanish bull fight would be distinguishable archaeologically from butchery marks. However, the skulls would be noticeable for having no evidence of poleaxeing on the frontals. Structured deposition, *sensu* Fulford (2001), is becoming more commonly recognised on Romano-British sites and complete cattle skulls are frequently encountered in such contexts, as noted previously.

The British tradition of bull baiting had a superficial resemblance to the modern Azores street practice, in that the bull was restrained on a long tether. However, instead of being teased by young men, the bull was attacked by the specialist breeds of bull dogs. This was a peculiarly British bull sport and the British Bulldog is still symbolic of national identity. The public order offences associated with bull baiting in the years prior to parliamentary reform led to the outlawing of bull sports in Britain in the early 19th century.

Several points need emphasising from this brief overview. There is a strong link between bull sports and religious festivals, particularly those associated with agricultural fertility. The latter are more likely to be bloodless. Bull sports are performed by both men and bulls at a developmental stage when both need to establish a dominant position in their social rank hierarchy to achieve breeding rights. This is particularly apparent with rite of passage "Jumping of the Bull" of the Hamar in southwest Ethiopia (http://fotobank.ru/image/JW00-6025.html). Some aspects of bull sports may be performed only by either patrician or plebeian participants but these can form complementary parts of the overall spectacle. Mounted blood sports are generally associated with nobility and the associated hunting and military ethos. By extension, success in this field and the possession of the appropriate quarry become part of the trappings of power and authority. This point returns to the Chillingham herd and the killing of the King Bull. Hemming (2002, 76-7) summarises the medieval accounts of woodland, or wild, cattle as possible ancestors of white park cattle. Since the earliest mention is the forest law of Cnut, the association of such free-living cattle as quarry for the hunt appears plausible, leading to subsequent emparkment with other managed game, such as the fallow deer.

As the expression "taking the bull by the horns" indicates, the horns of the bull are vital for bull sports. The Iberian bulls, such as Alcalde in Plate 2: 7, are bred to have horns with the outward, inward and upward curves seen in the aurochs, described as the primigenius spiral (Grigson 1976, 132-3). Bulls with wide horns make it difficult for the *toreros* to work near the bull with the cape (Lewine 2005, 58). The primigenius horn shape is also seen in the Minoan wall paintings. The uniquely British bull-baiting with dogs could have arisen because bulls of British cattle breeds may not exhibit this horn pattern. For example, though of French origin, the modern Limousin can have the required temperament for bull fighting. All the people known personally to the author who have been seriously hurt by cattle have had encounters with Limousins. However, the breed has two disadvantages. It is too tall and the horns, when not dehorned, are of the shape referred to archaeologically in Britain as "Celtic Shorthorn", Plate 2:9.

Bull sports are not static. The Iberian tradition has, in the past 300 years, seen change from a mounted display by nobility to an on foot spectacle by plebeian participants. Even in the 20th century, the emphasis moved from the *picador*, after the introduction of padding for the horses, to the *matador* displaying artistry with the

cape. Breeders have responded by selecting for bulls with different attributes for the bullring. Although the cattle herds supplying the bullring are run on range conditions with a semi-feral lifestyle, these animals have a respectable 18th century pedigree of improvement, comparable to the thoroughbred horse, as 40% of modern Spanish *corrida* bulls descend from one foundation herd (Lewine 2005, 58). Lewine (55-58) considers the early 18th century Spanish cattle breeders to be among the first to practice selective breeding to produce desired traits in the offspring. Since aggression, speed, small size, late maturity and primigenius horns are among these traits, this makes a mockery of the concept of "improvement", even in an 18th century sense, as equating with large size, docility and an ability to fatten quickly. The modern Spanish bull Alcalde in Plate 2:7 has what would be considered faults in conformation by both beef and dairy breeders. Despite this, his value and the financial return generated by his sons in the *corrida* are far more than the average herd could aspire to. Such characteristics also have implications for the "wildness" of white park cattle, particularly the extant Chillingham herd. Emparked cattle may have been subject to similar rigorous selection to enhance the kudos of killing the King Bull.

Appendix 3: 1. Aseasonal Breeding and Calf Survival

Aseasonal Breeding

In Chapter 2, the influence of environment and sire selection on aseasonal breeding was considered. Now the topic will be viewed from the evidence of the progeny. With either wild species, such as deer, with a pronounced rut or domestic species, such as sheep, with a seasonal breeding pattern, the presence of infant animal bones can be used as an indicator of the season of human deposition of the context in which such bones occur. Assumptions have been made that domestic archaeological cattle will also have conformed to such a restricted pattern of breeding.

Balasse and Tresset (2007) acknowledged that domestic cattle can breed throughout the year but postulated seasonal breeding for the Neolithic Orkneys and substantiate this proposal by a study of isotopes in tooth enamel. The Orkneys are, however, an extreme environment and less restricted evidence for seasonality was observed by Balasse and Tresset for Neolithic calf teeth from an island off the coast of Brittany.

Hall and Hall (1988, 483) quantified births by month in the Chillingham herd and found no obvious seasonality of breeding, Figure 3: 1. The Chillingham herd was certainly extant in the 17th century and possibly emparked in the 13th century (Bilton 1957, 137-8). There is now no human interference with breeding, so this herd implies that it was feasible for 15th century cattle to have bred year-round, *contra* O'Connor (2008b, 90). Hall and Hall (1988, 490) further observed that Chillingham calves born later in the year have enhanced survivability in their first year compared to calves born earlier in the year. For the Chillingham cattle, Hall and Hall (1988, 490-91) suggested that the relatively abundant grass of May and June was utilised to the calf's advantage as *in utero* growth rather than consumption of the dam's milk yield. However Selk's (2008) data from cattle in Oklahoma and Colburn *et al* (1996) for Nebraska indicate that calves born in summer and autumn have lower body weights than those born in winter and spring. The later calving Chillingham cows may be utilising the spring grass to improve their body condition in advance of, and to sustain, lactation, enhancing post-partum rather than foetal growth in the calves. Matos *et al's* (2002) study of Mertolenga cattle in southern Portugal, on low input range conditions, showed that the dam's milk production was crucial for calf growth

in the first three months of life but less important thereafter, when calves were grazing and receiving supplementary feed.

The Heck cattle on the Oostvordersplassen nature reserve near Amsterdam are a further example of an unmanaged breeding cattle population, having less human contact than the Chillinghams. The data for 2003, (Cis van Vuure pers. comm.), in Figure 3: 1, compares the months in which Heck calves were born *and survived* (author's emphasis) with the data for the Chillinghams. While the majority of calves were born in March-June, there is a consistent, if low, number of viable births recorded for July-November. Only in December, January and February are no Heck calves recorded as born and surviving in this particular year.

In a totally different environment, Figure 3: 2 shows months of calving for indigenous cattle in the central Ethiopian highlands (Mukasa-Mugerwa 1989). It can be seen that while calving peaks in May, births occur in all months, with a smaller peak of births in October-November.

In contrast, in the author's Zanfara herd, Figure 3: 3 shows that most births occur in January-March with a tail from April to September and one record in December, pre-empting the normal January calvings. No births have ever occurred in this herd in October-November. The explanation of this pattern is linked to three factors. One is historical. The foundation cow, Chalena 6th of Zelston, first calved in January, predicated by the availability of a hire bull. Secondly, the Zanfara cows and calves are turned out, depending on weather, anytime between March and May. Turn out, with extra photoperiod, exercise and fresh grass, about six to eight weeks after calving stimulates the cows to come bulling and means they are fertile, generally holding to the first or second service. The herd calving pattern is thus perpetuated. Thirdly, home-bred heifers generally come bulling at about 15 months old, to calve down on, or about, their second birthday, further perpetuating the herd calving pattern. The system works well for this herd in this situation. Both cows and calves benefit from the spring grass when the cows are at the peak of the lactation curve, see Chapter 4. Heifer calves are generally at least six months old and able to be weaned for sale at the annual rare breed sale in October. Bull calves can go for slaughter as baby beef (note **not** veal) in November or January. The births later in the year represent years when turn out was very late, bought in animals, cows that failed to hold before the bull was hired out, delayed mating caused by movement restrictions during the Foot and Mouth outbreak and other similar variables. Balasse and Tresset

(2007, 74) suggest that it may not have been easy to shift the cattle breeding season in early societies dependent on an annual cycle of pasture. This may well have been so. In theory, the principle requirement is merely to have some means of keeping the bull from the cows, once post-partum oestrus cycles commence, until the desired month for mating. In practice, the Zanfara herd calves at its own convenience.

The Zanfara herd is a suckler herd. The Knotting dairy herd of Dexters might be expected to be more comparable with archaeological, dairy oriented, cattle. Figure 3:4 shows a normal bell-curve distribution of births throughout the year, with the peak of calvings spread from June to September.

There may be unexpected benefits to rearing out of season calves. Hall & Hall (1988, 490) were surprised that late-born Chillingham calves tended to have enhanced survivability to one year old compared to early-born calves. Wet, rather than cold, weather is the main cause of mortality in the Chillingham herd, with rainfall levels between January and May being critical (Hall & Hall 1988, 491). Calves born later in the year are not subject to this severe selection pressure. Though the Zanfara calves are mostly born between January and May in a more exposed location than Chillingham Park, they are born indoors. The barn is by no means weather tight but even with this fairly minimal protection from wind and wet, calf mortality is very low. Without the shelter of the barn, mortality would be catastrophic.

Autumn born dairy heifer calves were observed by Morley (1950, 93) to be less susceptible to disease. A quarter of the calves born in spring succumbed to disease compared to less than a tenth of the autumn born calves. The highest calf death rate was between February and April. The season of birth affected the subsequent growth rate of heifers, with those born October-December having the highest live weight gain to 700 days old and those born April-June having the lowest. Heifers born in April showed the lowest weight gain of all. The advice on killing spring born calves and rearing autumn born calves for the dairy, given by Markham (Best 1986, 168-9), is thus vindicated by scientific observation and quantification of both traditionally managed dairy cattle and a feral herd. Also, such a pragmatic cull strategy of more vulnerable spring-born calves may partly explain genetic resistance to diseases, quantified in mid 20th century dairy cattle, and considered to result from intense selection for resistance (Spooner *et al* 1975). Selection pressure on calf rearing based on empirical observation, passed down for generations, can be seen to

have been effective advice, though not selection in any modern sense from good-looking or high-performing parents.

Survivability of autumn born calves

As a practical example of the survivability of autumn born calves, in the Zanfara herd, the two calves in Figure 3: 3 born in August and September, Olivine and Pyrite, were full siblings and dark dun in colour. Rebekanda, a closely related spring-born heifer, was also of this coat colour. The two calves were out-wintered with their dam in successive years. Both calves experienced prolonged spells of bitter cold and snow, with only access to lean-to field shelters. A failed attempt was made to house Pyrite, at an age when ready for weaning, during particularly severe weather but he rejoined his dam and wintered outside. The dun coat colour in these three youngstock appears to have preserved the double winter coat, with short woolly undercoat and long hairy outer coat, known for the aurochs, Heck cattle and both Neolithic and medieval archaeological samples from Britain (van Vuure 2005, 160-163). Plates 3:3a-e show details of this coat. It was very noticeable with the two calves that the long guard hairs shed water, so that the woolly undercoat remained dry. The Chillingham calves do not exhibit this double coat, which may partly explain their susceptibility to cold wet weather. Conversely, the presence of this double coat in medieval cattle may indicate a continuing response to winter weather. The double coat appears to be linked to the dark dun colour, as neither the red nor black animals in the Zanfara herd exhibit this trait, despite close relationship to the dun animals.

Dry cold is not generally a cause of problems with calf survival. Many Heck cattle breeders in Germany have posted photographs on the internet of tiny calves in the snow. These herds generally have woodland for shelter and ample fodder provided.

Calf Birth Weights

Calf birth weights are a possible source of proxy information for the amount of variation that might be expected in the size of the bones of new-born calves, in addition to the actual reference skeletons.

Hall and Hall (1988, 490) note that calf birth weight can influence the milk yield of the dam, with heavier calves appearing to both demand and receive more milk. Though it was not possible to weigh new born Chillingham calves, Hall and

Hall (1988, 490) accepted evidence indicating a 3kg difference in mean birth weight between bull and heifer calves and suggested that this might impact on the survival rate for heifer calves in the first month of life. However, Holland *et al* (1977) found a difference of only 1.86kg in the mean birth weights of male and female Angus and Hereford calves in Australia and, given the small size of the Dexter, a large disparity in weight between bull and heifer calves seemed inherently unlikely for this breed, and, by extension, archaeological Dexter-sized cattle and possibly also the Chillinghams. Furthermore, the presence of the short and non-short legged phenotypes within the Dexter could potentially show variation in calf birth weights and sizes, not seen in other breeds.

Calf birth weight is also an important factor with regard to dystocia, particularly in primagravida heifers. The season of the year during the last trimester of pregnancy has more impact on calf birth size than the diet or body condition of the dam. Exceptionally cold weather in winter increases calf birth weight as the concentration of blood internally by the dam, to maintain core body temperature, has the side effect of increasing the blood and nutrient flow to the foetus, thus enhancing growth Colburn *et al* (1996). Conversely, autumn born calves are lighter because the blood flow of cows gestating in hot weather will be circulated to the extremities to dissipate heat, so reducing the nutrients supplied to the foetus (Selk 2008). This pattern has been observed irrespective of the body condition of the dam.

It can be seen that the seasonality of calving discussed above is integral to the birth weight and survivability of the calf and so part of the rationale of decision making by cattle breeders.

Appendix 3: 2. Archaeological Ageing Schemes

The system used by Noddle (1983, 94):

N, newborn. All bones small, no fused epiphyses, all dentition temporary and unworn.

W, weaning. Bones slightly larger than above but still retaining newborn character. No epiphyses fused. All dentition temporary with the exception of molar 1, showing some wear.

J, juvenile. No epiphyses fused except scapula. Bones larger than above but not full-sized. Temporary incisors and premolars still present, M2 in wear and M3 not present. In modern terms these animals would be up to c. 18 months in age, but modern data cannot be strictly applied to these ancient types.

I, immature. Earliest epiphyses fused (proximal radius, distal humerus, phalanges). Intermediate epiphyses may be fused (distal metapodial, tibia) but not the late group (proximal humerus, tibia, both ends femur, distal radius, ulna and calcaneum, vertebrae). Permanent premolars may be present but not much worn. Third molar present but not in full wear, some temporary incisors present. In modern terms these animals will range from c. 18 months to four years.

M, mature. All epiphyses fused. All permanent teeth fully in wear.

O'Connor (2003, 160) proposed a refined version of this type of scheme but applicable only to mandibles, not epiphysial fusion events:

N, Neonatal, DP4 unerupted or just in the process of eruption

J, Juvenile, DP4 in wear, LM1 not in wear

I, Immature, LM1 in wear, LM2 not in wear

SA, Sub-adult, LM2 in wear, LM3 not in wear

- **SA1**, LM3 forming, to just erupting through the alveolar bone
- **SA2**, LM3 erupting through bone to occlusal plane

A, Adult, LM3 in wear

- **A1**, LM3 up to minor dental exposure on mesial column, TWS a & b
- **A2**, LM3 dentine exposure across central column, TWS c & d
- **A3**, LM3 dentine exposure on distal column, TWS e to h

E, Elderly, dentine exposure to or beyond TWS j

Appendix 4: 1 Milk and calving records for Vycanny cows in reference collection

Lactation	Days in milk	Kgs milk	Butterfat%	Calving Record	
Vycanny Finbar's Glenteitney					
1	305	1593	3.69	25/08/1976	Bull
2	293	2232	3.47	24/04/1978	Heifer
3	305	2245	3.72	09/04/1979	Bull
4	305	2816	4	21/04/1980	Heifer
5	304	3115	3.51	26/04/1982	Bull
6	283	2203	3.81	02/03/1984	Bulldog
7	269	2096	3.4	04/05/1985	Heifer
8	305	1904	3.61	19/06/1986	Heifer
9	277	2116	3.64	04/05/1988	Heifer
				28/02/1989	Bulldog
Vycanny Dormouse's Glenfinlet					
1	305	2252	4.21	17/05/1982	Heifer
2	305	1880	4.64	12/07/1983	Bull
3	305	2380	4.58	27/06/1984	Bulldog
4	287	2277	4.52	28/01/1986	Bull
5	274	2207	4.35	17/05/1987	Bull
6	253	2270	4.31	21/04/1988	Heifer
7	305	2101	4.69	04/05/1989	Bull
				25/04/1990	Bull
Vycanny Dalesman's Kirstie					
1	305	1973	4.63	22/05/1982	Bull
2	305	2077	4.61	21/05/1984	Heifer
3	276	1963	4.32	30/05/1985	Bull
4	305	2828	4.42	08/05/1986	Heifer
5	248	2037	4.51	27/05/1987	Heifer
6	278	1950	4.43	06/05/1988	Heifer
7	238	1744	4.53	22/04/1990	Bull
8	271	2112	4.49	09/04/1991	Heifer
				07/04/1992	Heifer
10	263	1223	4.58	12/07/1993	Bull
				29/06/1994	Bull
Vycanny (Pug's) Keepsake (NB no milk records published)					
				23/03/1994	Bull
Erratum: Recorded as Kirstie's but born after her death				21/04/1995	Bull
				30/05/1996	Bull
				19/05/1997	Bull
				11/06/1998	Bull
				12/02/2000	Heifer

Appendix 5: 1. Zanfara Cull Cows

Jaqueena Born 18/1/89 OTMS 27/9/99
Progeny
12/3/91 Steer, Bantu (reference collection Chapter 6)
24/3/92 Heifer, Laura
23/3/93 Heifer, Lauretta
27/3/94 Bull, Manzara
16/3/95 Heifer, Lauranda
3/3/96 Heifer, Laurobina
12/2/97 Heifer, Lauraquinta
25/1/98 Heifer, Lauraline

Jaquetta Born 10/2/90 OTMS 8/6/98
Progeny
13/3/92 Heifer, stillborn (reference collection Chapter 3)
3/3/93 Bull, Caesar
9/2/94 Bull, Dozey (reference collection Chapter 3)
16/1/95 Heifer Amelia
4/12/96 Heifer Amelietta

Jaquinta Born 6/3/94 Died on farm 14/4/03
Progeny
1/6/96 Bull Quince
7/4/97 Bull Medlar (reference collection Chapter 3)
24/2/98 Heifer Antonia
9/2/99 Heifer Antoinette
8/2/00 Bull Marmalade (reference collection Chapter 3)
6/4/01 Heifer Antonianda
24/3/02 Bull Antonius
4/2/03 Heifer Antoniabina

Lauretta Born 23/3/93 Sold/OTMS 5/10/03
Progeny
23/3/95 Heifer Laurel
10/3/96 Heifer Laurelite
10/3/97 Bull Lawrence
27/1/98 Bull Laud
12/2/99 Bull Lawson
28/1/00 Heifer Laurelanda
10/4/01 Bull Laurie
29/3/02 Heifer Laurelobina
18/2/03 Bull Laureate

Antoinette Born 9/2/99 Put down 26/9/08
Progeny
22/3/01 Heifer Cassaena
2/3/03 Bull Versailles
8/2/04 Bull Mazarin
23/2/05 Bull Louis

16/4/06 Bull Trianon
2/1/08 Bull Aramis

Laurelite Born 10/3/96 Put down 24/3/10
Progeny
25/2/98 Bull Zircon
6/3/99 Heifer Yttrium
10/2/00 Bull stillborn
15/1/01 Heifer Wollastonite
13/2/02 Bull Vivianite
20/1/03 Heifer Uvarovite
25/1/04 Bull Titanium
20/2/05 Bull Siderite
18/2/06 Bull Rhyolite
7/3/07 Bull Quartz
21/8/08 Bull Pyrite
19/7/09 Heifer Olivine

Appendix 6: 1. List of oxen in Boldon Book requisitioned for carting the Bishop of Durham's wine.

Plawsworth, Simon Veal holds, carts wine with 8 oxen

Little Usworth, William holds, carts wine with 8 oxen

Little Burdon, John of Houghton holds, carts wine with 4 oxen

West Auckland, Elstan the dreng (deceased) used to cart wine with 4 oxen

Lutterington, Geoffrey of Lutterington carts wine with 4 oxen

Cornsay, Simon the chamberlain carts wine with 12 oxen

Greencroft carts wine with 4 oxen

Iveston carts wine with 8 oxen

Holmside carts wine with 4 oxen

Hulam carts wine with 6 oxen

Oxen le Flats, William carts wine with 4 oxen

Whessoe, Robert provides 4 oxen for leading wine

Thickley, Guy of Redworth carts wine with 4 oxen

References

Agerholm J. S., Bendixen, C., Andersen, O. & Arnbjerg, J. 2001. Complex vertebral malformation in Holstein calves. *Journal of Veterinary Diagnostic Investigation* **13**: 283-9.

Albarella, U. 1999. 'The mystery of husbandry': medieval animals and the problem of integrating historical and archaeological evidence. *Antiquity* **73**: 867-75.

Albarella, U. & Davies, S. 1996 for 1994. Mammals and Birds from Launceston Castle, Cornwall: decline in status and the rise of agriculture. *Circaea* **12** (1): 1-156.

Allen, L. F. 1872. *History of the Short-Horn Cattle: their origin, progress and present condition*. Warren, Johnson & Co.: Buffalo, N.Y.

Alvares, C. 1985. *Another Revolution Fails*. Ajanta Publications: Delhi.

Amorosi, T. 1989. *A Postcranial Guide to Domestic Neo-Natal and Juvenile Mammals*. BAR International Series **533**: Oxford.

Amoroso, E. C. & Jewell, P. A. The Exploitation of the Milk-Ejection Reflex by Primitive Peoples. In A. E. Mourant & F. E. Zeuner (eds) *Man and Cattle*. Royal Anthropological Institute: London, 126-137.

Andersson, E. I. The Perfect Picture – A Comparison between Two Preserved Tunics and 13th-Century Art. In E. Andersson Strand, M. Gleba, U. Mannering, C. Munkholt & M. Ringgaard (eds). *North European Symposium for Archaeological Textiles X*. Oxbow Books: Oxford, 4-8.

Annandale, C. H. 2007. *Mechanisms by which lumpy skin disease virus is shed in semen of artificially infected bulls*. MMedVet (Gyn) thesis. University of Pretoria.

Anon (W. M.) 1984 facsimile of 1655. *The Compleat Cook and A Queen's Delight*. Prospect Books: London.

A. Appadurai (ed.) 1986. *The social life of things: commodities in cultural perspective.* Cambridge University Press.

Archaeological Services 2006. *Alnwick Castle, Alnwick, Northumberland: Archaeological Monitoring.* Archaeological Services Durham University Report **1502**.

Archaeological Services 2007a *Tuthill Stairs, Newcastle upon Tyne: palaeoenvironmental analysis.* Archaeological Services Durham University Report **1646**.

Archaeological Services 2007b. *Kingsley Fields, Welsh Row, Nantwich, Cheshire: plant macrofossils, wood, diatoms, faunal remains and beetle analysis*. Archaeological Services Durham University Report **1485**.

Archaeological Services 2011. *Ripon Market Place archaeological excavation; full analysis report*. Archaeological Services Durham University Report **2639**.

Armitage, P. L. 1994. Unwelcome companions: ancient rats reviewed. *Antiquity* **68**: 231-40.

Arrillaga, C. G. 1949. Dwarf Cattle for the Tropics. *Journal of Heredity* **40** (6): 167-8.

Austin, D. (ed.) 1982. *Boldon Book*. Phillimore: Chichester.

Austin, D. 2007. *Acts of Perception: A study of Barnard Castle in Teesdale*. Architectural and Archaeological Society of Durham and Northumberland Research Report **6**: Durham.

Austin, T. 1888. *Two Fifteenth-Century Cookery-Books*. Early English Text Society: London.

Backhouse, J. 2000. *Medieval Rural Life in the Luttrell Psalter*. The British Library: London

Baker, J. & Brothwell, D. 1980. *Animal Diseases in Archaeology*. Academic Press: London.

Balasse, M & Tresset, A. 2007. Environmental constraints on the reproductive activity of domestic sheep and cattle: what latitude for the herder? *Anthropozoologica* **42** (2): 71-88.

Barber, R. 1999. *Bestiary*. The Boydell Press: Woodbridge.

Barnes, E. 1994. *Developmental Defects of the Axial Skeleton in Paleopathology*. University Press of Colorado.

Bar-Oz, G., Dayan T. & Kaufman 1999. The Epipalaeolithic faunal sequence in Israel: a view from Neve-David. *Journal of Archaeological Science* **26**: 67-82.

Bar-Oz, G., Dayan, T., Kaufman D. & Weinstein-Evron, M. 2004. The Natufian Economy at el-Wad Terrace with special reference to gazelle exploitation patterns. *Journal of Archaeological Science* **31**: 217-231.

Barron, N. 1950. *The Dairy Farmer's Veterinary Book*. Dairy Farmer (Books) Ltd: Ipswich.

Bartlett, R. (ed.) 2001. *Medieval Panorama*. Thames & Hudson: London

Bartosiewicz, L., van Neer, W. & Lentacker, A. 1997. *Draught Cattle: their osteological identification and history*. Annales Sciences Zoologiques 281: Tervuren.

Basing, P. 1990. *Trades and Crafts in Medieval Manuscripts*. The British Library: London

Baxter, I. L. 2007. *Poaching by tethered horses*. http://www.alexandriaarchive.org/icaz/icazForum/newtopic.php?t=875

Beaudry, M. C. 2007. *Findings: the material culture of needlework and sewing*. Yale University Press: New Haven.

Beeton, I. 1982 facsimile of 1861. *Book of Household Management*. Chancellor Press. London.

Bender Jørgensen. L. 2005. Textiles of Seafaring: an Introduction to an Interdisciplinary Research Project. In F. Pritchard & J. P. Wild (eds) *Northern Archaeological Textiles, NESAT VII*. Oxbow Books: Oxford, 65-69.

Best, M. R. (ed.) 1986. *Gervase Markham: The English Housewife*. McGill-Queen's University Press: Kingston.

Bewick, T. 1980 facsimile of 1807. *A General History of Quadrupeds*. Windward: Leicester.

Bewick, T. no date 1862 facsimile. *Thomas Bewick*. Quince Tree Press: Alnwick.

Bietak, M, Marinatos, N. & Palivou, C. 2007. *Taureador Scenes in Tell el Dab'A (Avaris) and Knossos*. Osterreichischen Akadamie der Wissenschaft: Vienna.

Bilton, L. 1957. The Chillingham Herd of Wild Cattle. *Transactions of the Natural History Society of Northumbria* **12**: 137-160.

Board on Agriculture (National Research Council) 2000. *Nutrient Requirements of Beef Cattle.* National Academy Press: Washington D.C.

Bone, J. F. 1963. Dwarfism in Cattle. *Modern Veterinary Practice* **44**: 37-40.

Brears, P. (ed.) 2003. *The Boke of Keruynge*. Southover Press: Lewes.

Brereton, G. E. & Ferrier, J. M. 1981. *Le Menagier de Paris*. Clarendon Press: Oxford.

Brimley Johnson, R. (ed.) 1906. *The Poems of Thomas Love Peacock*. Routledge: London.

Britnell, R. 2004. Fields, farms and sun-division in a moorland region, 1100-1400. *Agricultural History Review* **52** (1): 20-37.

Broad, J. 1984. Cattle Plague in Eighteenth-Century England. *Agricultural History Review* **31** (2), 104-115.

Brothwell, D., Dobney, K. and Ervynck, A. 1996. On the Causes of Perforations in Archaeological Domestic Cattle Skulls. *International Journal of Osteoarchaeology* **6**, 471-487.

Brothwell, D., Dobney, K. & Jaques, D. 2005. Abnormal sheep metatarsals: a problem in aetiology and historical geography. In J. Davies, M. Fabis, I. Mainland, M. Richards and R. Thomas (Eds) *Diet and Health in Past Animal Populations*. Oxbow Books: Oxford, 75-9.

Brown, M. P. 2006a. *The World of the Luttrell Psalter*. The British Library: London.

Brown, M. P. (ed.) 2006b. *The Luttrell Psalter*. Folio Society: London.

Bunning, A. 2007. Cob making with Dexters. *The Dexter Cattle Society Bulletin* **164**: 14-5.

Camille, M. 1992. *Image on the Edge: The Margins of Medieval Art*. Reaktion Books: London.

Caple, C. 2007. *Excavations at Dryslwyn Castle 1980-95*. Society for Medieval Archaeology Monograph **26**: Leeds.

Cavanagh, J. A., Tammen, I., Windsor, P. A., Bateman, J. F., Savarirayan, R., Nicholas, F. W. & Raadsma, H. W. 2007. Bulldog dwarfism in Dexter cattle is caused by mutations in ACAN. *Mammalian Genome* **18** (11): 808-14.

Childe, V. G. 1936. *Man Makes Himself*. Watts & Co.: London.

Clutton-Brock, J. 1981. *Domesticated Animals from Early Times*. British Museum (Natural History): London

Cobbett, W. 1979 facs of 1850. (1st edn 1822) *Cottage Economy*. Oxford University Press: Oxford.

Cobbett, W. (Dyck, I. ed) 2001. (1st edn 1830) *Rural Rides*. Penguin Classics: Harmondsworth.

Cobbett, W. 1983 facs. of 1819. *Journal of a Year's Residence in the United States of America*. Alan Sutton: Gloucester.

Cochrane, E. R. 1946. *The Milch Cow in England*. Faber & Faber Ltd: London.

Coghill, N. and Tolkien, C. (eds) 1959. *Chaucer: The Nun's Priest's Tale*. Harrap & Co. Ltd: London

Colburn, D., Deutscher, G & Olson, P. 1996. *Winter Temperatures May Affect Calf Birth Weights*. Nebraska Beef Cattle Report: University of Nebraska.

Cole, G. D. H. and Cole, M. (eds) 1930. *Rural Rides Volume III*. London: Peter Davies.

Cole, S. 1970. *The Neolithic Revolution*. British Museum (Natural History): London.

Collingwood, R. G. 1966. *The Idea of History*. Oxford University Press: Oxford

Cool, H. E. M. 2006. *Eating and Drinking in Roman Britain*. Cambridge University Press: Cambridge.

Comben, N. 2007. *The Durham Ox*. Adlard Print & Reprographics: Nottingham.

Cope, C. 1991. Gazelle Hunting Strategies in the Southern Levant. In O. Bar-Yosef & F. R. Valla (Eds) *The Natufian Culture in the Levant*. International Monographs in Prehistory **1**: Michigan, 341-358.

Costen, M., Gerrard, C., Aston, M. & Hall, T. 2007. The early Middle Ages, Domesday and beyond. In C. Gerrard & M. A. Aston (eds) *The Shapwick Project, Somerset. A Rural Landscape explored*. Society for Medieval Archaeology Monograph **25**: 26-31.

Crew, F. A. E. 1924a. The Bull-dog Calf: A Contribution to the Study of Achondroplasia. *Proceeedings of the Royal Society of Medicine* **XII**: 39-58.

Crew, F. A. E. 1924b. The Significance of an Achondroplasia-like Condition met with in Cattle. *Proceedings of the Royal Society of London Series B* **XCV**: 228-255.

Cripps-Day, F. H. 1931. *The Manor Farm*. Bernard Quaritch Ltd: London

Crossley-Holland, N. 1996. *Living and Dining in Medieval Paris*. University of Wales Press: Cardiff.

Cupere, B. de, Lentacker, A. N., Neer, W. van, Waelkens, M. & Verslype, L. 2000. Osteological evidence for the draught exploitation of cattle: first applications of a new methodology. *International Journal of Osteoarchaeology* **10**: 254-267.

Curran, P. L. 1990. *Kerry and Dexter Cattle*. Royal Dublin Society: Dublin.

Cussans, J. E. & Bond, J. M. 2010. The Animal Bone. In I. Ferris *The Beautiful Rooms Are Empty.* Durham County Council: Durham.

Cymbron, T., Freeman, A. R., Malheiro, M. I., Vigne, J-D. & Bradley, D. G. 2005. Microsatellite diversity suggests different histories for Mediterranean and Northern European cattle populations. *Proceedings of the Royal Society B* **272** (1574): 1837-1843.

Dahl, G. & Hjort, A. 1976. *Having Herds: Pastoral Herd Growth and Household Economy.* University of Stockholm.

Daniels, R. 2002. Medieval Boroughs of Northern England. In C. Brooks, R. Daniels and A. Harding (eds) *Past, Present and Future: The Archaeology of Northern England*. Durham: Architectural and Archaeological Society of Durham and Northumberland Research Report **5**, 185-197.

Daniels, R. 2010. *Hartlepool: An archaeology of the medieval town*. Tees Archaeology Monograph Series **4:** Hartlepool.

d'Anthenaise, C. 2002. *The Hunting Book of Gaston Phébus*. Hackberry Press: Texas.

Dar, G. & Herschkovitz, I. 2006. Sacroiliac Joint Bridging: Simple and Reliable Criteria for Sexing the Skeleton. *Journal of Forensic Science* **51 (**3): 480-483.

Darwin, C. 1994 facsimile of 1872. *The Origin of Species*. Studio Editions Ltd: London.

Davies, R. R. 1978. *Lordship and Society in the March of Wales 1282-1400*. Oxford University Press.

Davis, S. J. M. 1981. The effects of temperature change and domestication on the body size of Late Pleistocene to Holocene mammals of Israel. *Paleobiology* **7** (1): 101-114.

Davis, S. J. M. 1987. *The Archaeology of Animals*. B. T. Batsford Ltd: London.

Davis, S. J. M. 1987b. Cattle Foot Bones Excavated in 1982 from a Seventeenth/Eighteenth Pit in Church Street, Dorchester, Dorset. *Ancient Monuments Laboratory Report* **222/87**.

Day, I. (ed.) 2004. *The Art of Cookery by John Thacker, 1758*. Southover Press: Lewes.

Dean, S. C & Clough, U. M. 1974. *Darlington As It Was*. Hendon Publishing Co. Ltd: Hendon Mill.

Degerbøl, M. & Fredskild, B. 1970. *The Urus (Bos Primigenius Bojanus) and Neolithic Domesticated Cattle (Bos Taurus Domesticus Linne) in Denmark.* Munksgaard: Copenhagen.

Dent, A. 1974. *Lost Beasts of Britain*. Harrap: London.

Detienne, M. & Vernant, J-P. 1989. *The Cuisine of Sacrifice Among the Greeks*. University of Chicago Press.

Dobney, K. M., Jaques, S. D. & Irving, B. G. 1996. *Of Butchers and Breeds. Report on vertebrate remains from various sites in the City of Lincoln*. Lincoln Archaeological Studies No. **5**: Lincoln.

Dobney, K., Hall, A. & Hill, M. 2000. Why did the chicken dig a hole? Some observations on the excavation of dust baths by domestic fowl and their implications for archaeology. In J.P Huntley & S. Stallibrass (Eds) *Taphonomy and Interpretation. Symposia of the Association for Environmental Archaeology No.* ***14.*** Oxbow Books: Oxford, 91-93.

Dobney, K., Jaques, D., Barrett, J. & Johnstone, C. 2007. *Farmers, Monks and Aristocrats: the Environmental Archaeology of Anglo-Saxon Flixborough*. Oxbow Books: Oxford.

Dods, M. 1988 facsimile of 1829. *The Cook and Housewife's Manual*. Rosters Ltd: London.

Doornbos, M., van Dorsten, F., Mitra, M. & Terhal, P. 1990. *Dairy Aid and Development*. Sage Publications: New Delhi.

Doney, J. M., Ryder, M. L., Gunn, R. G. & Grubb, P. 1974. Colour, Conformation, Affinities, Fleece and Patterns of Inheritance in the Soay Sheep. In P. A. Jewell, C. Milner & J. Morton Boyd (eds) *Island Survivors: The Ecology of the Soay Sheep of St Kilda.* Athlone Press: London, 88-125.

Douglas, C. and Rowlinson, P. 2009. Exploring stock managers' perceptions of the human-animal relationship on dairy farms and an association with milk production. *Anthrozoos*, Berg Publishing. DOI: 10.2752/089279307X224764.

Driesch, A. von den 1976. *A Guide to the Measurement of Animal Bones from Archaeological Sites*. Peabody Museum Bulletin 1: Harvard.

Driesch, A. von den & Boessneck, J. 1974. Kritische Anmerkungen zur Widerristhohenberechnung aus Langenmassen vor- und fruhgeschichtlicher Tierknochen. *Saugetierkundliche Mitteilungen* **22**, 325-48.

Duckham, A. N. 1963. *The Farming Year*. Chatto & Windus: London.

Dyer, C. 2002. *Making a Living in the Middle Ages: The People of Britain 850-1520*. Yale University Press: London.

Dyer, C. 2006. Seasonal Patterns in Food Consumption in the Later Middle Ages. In C. M. Woolgar, D. Serjeantson & T. Waldron (eds) *Food in Medieval England*. Oxford University Press: Oxford, 201-14.

Earwood, C. 1993. *Domestic Wooden Artefacts*. University of Exeter Press: Exeter.

Eckles, C. H. 1919. A Study of the Birth Weight of Calves. *Journal of Dairy Science* **2** (3), 149-258.

Ellet, E. F. 1857. *The New Cyclopaedia of Domestic Economy, and Practical Housekeeper*. New York: Stringer & Townsend.

Epstein, H. & Mason, I. L. Cattle. In I. L. Mason (Ed.) *Evolution of Domesticated Animals*. Longman: London.

Fabiš, M. 2005. Pathological alteration of cattle skeletons – evidence for the draught exploitation of animals? In J. Davies, M. Fabis, I. Mainland, M. Richards & R. Thomas (Eds) *Diet and Health in Past Animal Populations*. Oxbow Books: Oxford, 58-62.

Fabiš, M. and Thomas, R. 2011. Not Just Cattle: Cranial Perforations Revisited. *International Journal of Osteoarchaeology* **21**, 347-50

Fabre-Vassas, C. 1997. *The Singular Beast*. Columbia University Press: New York.

Farmer, D. L. 1969. Some Livestock Price Movements in Thirteenth-Century England. *Economic History Review* 2nd Series, **XXII (**1): 1-16.

Fenton, A. 1969. Draught Oxen in Britain. *Narodopisny Vestnik Ceskoslovensky* **III – IV**: 17-51.

Ferris, I. 2011. *Vinovia: The Buried Roman City of Binchester in Northern England*. Amberley Publishing: Stroud.

Fisher, D. C. 2009. Paleobiology and extinction of Proboscideans in the Great Lakes Region of North America. In G. Haynes (ed.) American Megafaunal Extinctions at the End of the Pleistocene. Springer: Netherlands, 55-75.

Fitzherbert, J. 1534. *The Boke of Hvsbandry*. London.

Fothergill, G. A. 1903. *Sketch Book. Part II*. James Dodds: Darlington.

Fox, H. S. A. 1986. The Alleged Transformation from Two-field to Three-field Systems in Medieval England. *Economic History Review* **XXXIX** (4), 526-548.

Fraser Darling, F. 1956. *A Herd of Red Deer*. Oxford University Press: Oxford.

Fulford, M. 2001. Links with the past: pervasive 'ritual' behaviour in Roman Britain. *Britannia* **32**: 199-218.

Fussell, G. E. 1966. *The English Dairy Farmer 1500-1900*. Frank Cass & Co. Ltd: London.

Fussell, G. E. 1972. *The Classical Tradition in West European Farming*. Fairleigh Dickinson University Press: Rutherford.

Galton, F. 1907. *Inquiries into Human Faculty and its Development*. J. M. Dent & Sons Ltd: London.

Garratt, P. & Garratt, J. 1988. Rearing calves with Dexters. *The Ark* **XV** (9): 316-9.

George, S. 1985. *Operation Flood*. Oxford University Press: New Delhi.

Geist, V. 1971. *Mountain Sheep: A Study in Behaviour and Evolution*. University of Chicago Press.

Gerrard, C. & Aston, M. (eds) 2007. *The Shapwick Project. A rural landscape explored*. Society for Medieval Archaeology Monograph **25**.

Gerrard, F. 1945. *Meat Technology*. Leonard Hill Ltd: London.

Gerrard, F. & Mallion, F. J. (eds) 1977. *The Complete Book of Meat*. Virtue: London.

Getty, R. 1975. *Sisson and Grossman's The Anatomy of the Domestic Animals*. W. B. Saunders Co.: London.

Gidney, L. J. 1989a. The Animal Bone in J. Nolan (ed.) The Medieval town defences of Newcastle upon Tyne: Excavation and Survey 1986-7. *Archaeologia Aeliana* 5th Series **17**: 49-50, 68-70.

Gidney, L. J. 1989b. The Mammal and Bird Bone. In C. O'Brien Excavations at Newcastle Quayside: the Crown Court site. *Archaeologia Aeliana* 5th Series **17**: 182-189.

Gidney, L. J. 1991a. Leicester, The Shires, 1988 Excavations: The Animal Bones from the Medieval Deposits at Little Lane. *Ancient Monuments Laboratory Report* **57/91**.

Gidney, L. J. 1991b. Leicester, The Shires, 1988 Excavations: The Animal Bones from the Medieval Deposits at St Peter's Lane. *Ancient Monuments Laboratory Report* **116/91**.

Gidney, L. J. 1994 The animal bone. In *Excavations on Westgate Road, Newcastle 1991*. Heslop, D.H., Truman, L. & Vaughan, J.E. *Archaeologia Aeliana* 5th Series **XXII**: 177-184

Gidney, L. J. 1995. Mammal Bone. In C. D. Morris, C. E. Batey & D. J. Rackham *Freswick Links, Caithness. Excavation and Survey of a Norse Settlement*. NABO Monograph **1**: 192-208.

Gidney, L. J. 1999. The Animal Bones. In A. Connor & R. Buckley *Roman and Medieval Occupation in Causeway Lane, Leicester*. Leicester Archaeology Monographs No **5**: 310-329.

Gidney, L. J. 2001. The Animal Bones. In L. Truman Excavations at Stockbridge, Newcastle upon Tyne, 1995. *Archaeologia Aeliana* 5th Series **29**: 191-209.

Gidney, L. J. 2003.The animal bones from the Hospital and Barrack XII. In N. Hodgson *The Roman Fort at Wallsend (Segedunum) Excavations in 1997-8*. Tyne and Wear Museums Archaeological Monograph **2**: 231-240

Gidney, L. J. 2007a. Earliest archaeological evidence of the Ancon mutation in sheep from Leicester, UK. *International Journal of Osteoarchaeology* **17** (3): 318-321.

Gidney, L. J. 2007b. The Animal Bone. In C. Gerrard & M. A. Aston (eds) *The Shapwick Project, Somerset. A Rural Landscape explored*. Society for Medieval Archaeology Monograph **25**: 895-922.

Gidney, L. J. & Caple, C. 2007. Food production and consumption in Wales: 13th to 15th centuries. In C. Caple *Excavations at Dryslwyn Castle 1980-95*. The Society for Medieval Archaeology Monograph **26**: 283-295.

Gidney, L. J. 2008. The Holme House Villa: The animal bone. In H.E.M Cool and D.J.P Mason (eds) *Roman Piercebridge*. The Architectural and Archaeological Society of Durham and Northumberland Research Report 7: 148-156.

Gidney, L. J. 2009. The Dun Cow and the Durham Ox: From Dairy to Beef in Eighteenth Century North-East England. In S. Baker, A. Gray, K. Lakin, R. Madgwick, K. Poole & M. Sandias (eds) *Food and Drink in Archaeology 2*. Prospect Books: Totnes, 38-45.

Gidney, L. J. 2012. Faunal Remains Analysis. In P. Arrowsmith & D. Power *Excavations at Kingsley Fields 2002*. BAR British Series **557**: Oxford, 158-169.

Gidney, L. J. 2013. *Vycanny Daleman's Kirstie: A cautionary example of skeletal lesions, often used for the interpretation of archaeological draught cattle, in the skeleton of a Dexter cow of known life history*. Poster presented at "Ploughing Ahead", Oxford.

Gidney, L. J. Forthcoming a. Murrain or Starvation? Catastrophic Cattle Mortality Events and their Repercussions, in Thomas, R.& Antikos, T. (eds.), *Animal disease in past human society*: Proceedings of the fourth ICAZ Animal Palaeopathology Working Group Conference. Atlanta: Lockwood Press.

Gidney, L. J. Forthcoming b. Shapwick: The Manorial Demesne Oxen, in Broderick, L. G., de Carle, D., Law, M. & Randall, C. E., (eds.), *Palaeoeconomy and Palaeoecology of South West Britain*. Oxford: Archaeopress.

Gilchrist, R. 2012. *Medieval life: archaeology and the life course*. Boydell: Woodbridge.

Glantz, M. H. (ed.) 1976. *The Politics of Natural Disaster*. Praeger Publishers: New York.

Glasse, H. 1983 facsimile of 1747. *The Art of Cookery made Plain and Easy*. Prospect Books: London.

Grant, A. 1982. The use of tooth wear as a guide to the age of domestic ungulates. In Wilson, B., Grigson, C. & Payne, S. (Eds) *Ageing and Sexing Animal Bones from Archaeological Sites*. BAR British Series **109**: 91-108.

Grant, I. F. 1995. *Highland Folk Ways*. Birlinn Ltd: Edinburgh.

Grant, M. (trans.) 1990. Translator's Introduction. *Tacitus: The Annals of Imperial Rome.* BCA: London.

Grant, M. (trans.) 1996. *Anthimus: On the Observance of Foods*. Prospect Books: Totnes.

Gratten, J., Wilson, A. J., McRae, A. F., Beraldi, D., Visscher, P. M. & Slate, J. 2008. A Localized Negative Genetic Correlation Constrains Microevolution of Coat Color in Wild Sheep. *Science* **319**: 318-320.

Green, P. B. 1899. *A History of Nursery Rhymes*. Greening & Co. Ltd: London.

Greenfield, H. J. 2010. The Secondary Products Revolution: the past, the present and the future. *World Archaeology* **42** (1): 29-54.

Gregory, P. W., Tyler, W. S. & Julian, L. M. 1966. Bovine Achondroplasia: The Reconstitution of the Dexter Components from Non-Dexter Stocks. *Growth* **30**: 393-418.

Grew, F & de Neergaard, M. 1988. *Shoes and Pattens. Medieval Finds from Excavations in London **2***. The Stationery Office: London.

Griffiths, R. A. 1994. *Conquerors and Conquered in Medieval Wales*. Alan Sutton Publishing Ltd, Stroud.

Grigson, C. 1974. The Craniology and Relationships of Four Species of *Bos*.1. Basic Craniology : *Bos Taurus* L. and its Absolute Size. *Journal of Archaeological Science* **1**: 353-379.

Grigson, C. 1975. The Craniology and Relationships of Four Species of *Bos*. 2. Basic Craniology : *Bos Taurus* L. proportions and angles. *Journal of Archaeological Science* **2**: 109-128.

Grigson, C. 1976. The Craniology and Relationships of Four Species of *Bos*. 3. Basic Craniology : *Bos Taurus* L. sagittal profiles and other non-measurable characters. *Journal of Archaeological Science* **3**: 115-136.

Grigson, C. 1978. The Craniology and Relationships of Four Species of *Bos*. 4. The relationship between *Bos primigenius* Boj. and *Bos Taurus* L. and its implication for the phylogeny of the domestic breeds. *Journal of Archaeological Science* **5**: 123-152.

Grigson, C. 1982. Sex and Age Determination of Some Bones and Teeth of Domestic Cattle: A Review of the Literature. In Wilson, B., Grigson, C. & Payne, S. (Eds) *Ageing and Sexing Animal Bones from Archaeological Sites*. BAR British Series **109**: 7-19.

Grimm, J. 2010. *Animal keeping and the use of animal products in medieval Emden (Lower Saxony, Germany)*. PhD thesis. Rijksuniversiteit: Groningen.

Groot, M. 2005. Palaeopathological evidence for draught cattle on a Roman site in the Netherlands. In J. Davies, M. Fabis, I. Mainland, M. Richards & R. Thomas (eds) *Diet and Health in Past Animal Populations*. Oxbow Books: Oxford, 52-57.

Grubb, P. 1974. Population dynamics of the Soay sheep. In P. A. Jewell, C. Milner & J. Morton Boyd (eds) *Island Survivors: The Ecology of the Soay Sheep of St Kilda.* Athlone Press: London, 242-272.

Guilbert, H. R. & Gregory, P. W. 1952. Some features of growth and development of Hereford cattle. *Journal of Animal Science* **11**: 3-16.

Habermehl, K.-H. 1975. *Die Altersbestimmung bei Haus- und Labortieren.* Parey: Berlin.

Hall, S. J. G. 1989. Behaviour of Chillingham Cattle. *Animal Behaviour* **38**: 215-225.

Hall, S. J. G. 2004. *Livestock Biodiversity*. Blackwell: Oxford.

Hall, S. J. G. 2008. A comparative analysis of the habitat of the extinct aurochs and other prehistoric mammals in Britain. *Ecogeography* **31**: 187-90.

Hall, S.J.G. 2012. A Walk on the Wild Side. *The Ark*: Spring, 14-15.

Hall, S. J. G. & Clutton-Brock, J. 1989. Two hundred years of British Farm Livestock. British Museum (Natural History): London.

Hall, S. J. G. and Hall, J. G. 1988. Inbreeding and population dynamics of the Chillingham cattle (*Bos taurus*). *Journal of Zoology* **216**: 479-493.

Hall, S. J. G. & Moore, G. F. 1986. Feral Cattle of Swona, Orkney Islands. *Mammal Review* **16** (2): 89-96.

Hammond, P. W. 1993. *Food and Feast in Medieval England*. Alan Sutton Publishing Ltd: Stroud.

Hansen, H-O. 1969. A Report on Imitative Ploughing Experiments with Replicas of a Prehistoric Ard of the Døstrup Type carried out in 1962-1968. *Tools and Tillage* **I** (2): 67-92.

Hartley, D. & Elliot, M. M. 1925. *Life and Work of the People of England AD 1500-1799.* B. T. Batsford: London

Hartley, D. & Elliot, M. M. 1931. *Life and Work of the People of England AD 1000-1499.* B. T. Batsford: London

Hartley, D. (ed.) 1969. *Thomas Tusser: His Good Points of Husbandry*. Cedric Chivers Ltd: Bath.

Hartley, D. 1985. *Food in England*. Futura: London.

Hartley, M. & Ingilby, J. 1981. *Life and Tradition in the Yorkshire Dales*. Dalesman Publishing Co. Ltd: Clapham via Lancaster.

Harting, J. E. 1880. *British Animals extinct within historic times with some account of British Wild White Cattle*. Truber & Co.: London

Hawthorne, C. & Kent, R. 2006. Acorn calves (chondrodystrophy). Flock & Herd Case Notes www.flockandherd.net.au/cattle/reader/acorncalf.html

Hay, D. 1976. *The Bullfight*. New English Library: London.

Heck, H. 1951. The Breeding-Back of the Aurochs. *Oryx* **1** (3): 117-122.

Henlein, P. C. 1959. *Cattle Kingdom in the Ohio Valley: 1783-1860*. University of Kentucky Press: Lexington.

Hellier, R. and Moorhouse, S. 1980. *Medieval Dairying*. Yorkshire Archaeological Society: Leeds.

Hemming, J. 2002. *Bos primigenius* in Britain: Or, Why Do Fairy Cows Have Red Ears? *Folklore* **113**: 71-82.

Henig, M. 1984. *Religion in Roman Britain*. B. T. Batsford Ltd: London.

Henisch, B. A. 1976. *Fast and Feast: Food in Medieval Society*. The Pennsylvania State University Press.

Henisch, B. A. 1995. In Due Season: Farm Work in the Medieval Calendar Tradition. In D. Sweeney (ed.) *Agriculture in the Middle Ages*. University of Pennsylvania Press.

Hieatt, C. B. 1980. The Roast, or Boiled, Beef of Old England. *Book Forum* **5**: 294-299.

Holland, B. J. M., Mullaney, P. D. & Hopkins, I. R. 1977. Breed and environmental factors affecting birth weight in Victorian beef cattle. *Australian Journal of Experimental Agriculture and Animal Husbandry* **17** (84): 5-9.

Holmberg, T. & Reiland, S. 1984. The influence of age, breed, rearing intensity and exercise on the incidence of spavin in Swedish dairy cattle. A clinical and morphological investigation. *Acta Veterinaria Scandinavica* **25**: 113-127.

Holmes, J. M. 1981. Report on the animal bones from the resonance chambers of the Whitefriars church, Coventry. In C. Woodfield, Finds from the Free Grammar School at the Whitefriars, Coventry, c. 1545 – c.1557/58. *Post-Medieval Archaeology* **15**: 126-153.

Hooper, W. D. & Ash, H. B. 1934. *Marcus Terentius Varro On Agriculture*. The Loeb Classical Library, William Heinemann Ltd. London.

Howard, M. M. 1963. The Metrical Determination of the Metapodials and Skulls of Cattle. In A. E. Mourant & F. E. Zeuner (eds) *Man and Cattle*. Royal Anthropological Institute Occasional Paper **18**: 91-100.

Huntley, J. P. & Stallibrass, S. 1995. *Plant and vertebrate remains from archaeological sites in northern England: data reviews and future directions*. Architectural and Archaeological Society of Durham and Northumberland Research Report **4**.

Hughes, H. V. & Dransfield, J. W. 1953. *McFadyeans' Osteology and Arthrology of the Domesticated Animals.* Bailliere, Tundall & Cox: London.

Hutchinson, W. 1787. *The History and Antiquities of the County Palatine of Durham*. Vol. 2. Hodgson & Robinsons: Newcastle.

Hutton, R. 1996. *The Stations of the Sun*. Oxford University Press.

Ingham, B. 2002. Dental Anomalies in the Chillingham Wild White Cattle. *Transactions of the Natural History Society of Northumbria* **62**: 169-175.

Ingram, A. 1979. *The Country Animal Doctor*. Shire Publications Ltd: Princes Risborough.

Ingram, J. (trans.) 1929. *The Anglo-Saxon Chronicle*. J. M. Dent: London.

Jameson, M. H. 1988. Sacrifice and Animal Husbandry in Classical Greece. In C. R. Whittaker (ed) *Pastoral Economies in Classical Antiquity*. The Cambridge Philological Society. Supplementary Volume **14**: 87-119.

Jennings, R. 1864. *Cattle and Their Diseases*. John E. Potter & Co.: Philadelphia.

Johannsen, N. N. 2005. Palaeopathology and Neolithic cattle traction: methodological issues and archaeological perspectives. In J. Davies, M. Fabiš, I. Mainland, M.

Richards and R. Thomas (Eds) *Diet and Health in Past Animal Populations*. Oxbow Books: Oxford, 39-51.

Johns, C. 2011. *Cattle: History, Myth, Art*. British Museum Press: London.

Johnstone, C. 1999. Looking a gift horse in the mouth: the problems of using archived and published biometrical data. In S. Anderson (ed.) *Current and Recent Research in Osteoarchaeology* **2**. Oxbow Books: Oxford, 48-50.

Jones, E. 1978. Disaster Management and Resource Saving in Europe, 1400-1800. In M. Flinn (ed.) *Proceedings of the Seventh International Economic History Congress*. University Press: Edinburgh, 21-28.

Jones, G. & Sadler, P. 2004. *Cattle mandibles – separating the adults from the old. The eruption of the cement-enamel-junction of the lower third molar as a way of defining old cattle.* Poster, Association for Environmental Archaeology Spring Meeting, Bradford.

Jones, G. & Sadler, P. 2012. Age at death in cattle: methods, older cattle and known-age reference material. *Environmental Archaeology* **17** (1): 11-28.

Jones, M. 2002. *The Secret Middle Ages*. Sutton: Stroud.

Jones, R. T., Wall, S. M., Locker, A. M., Coy, J. & Maltby, M. 1979. *Computer Based Osteometry Data Capture User Manual*. Ancient Monuments Laboratory Report **3342**.

Jones, R. T. & Ruben, I. 1987. Animal bones, with some notes on the effects of differential sampling. In G. Beresford *Goltho: the development of an early medieval manor c. 850-1150*. English Heritage Archaeological Report **4**. London: 197-206.

Joubert, D. M. & Hammond, J. 1954. Maternal Effect on Birth Weight in South Devon X Dexter Cattle Crosses. *Nature* **174**: 647-8.

Kershaw, I. 1973. The Great Famine and Agrarian Crisis in England 1315-1322. *Past and Present* **59**: 1-50.

Kinsella, T. (trans.) 1969. *The Tain*. Oxford University Press.

Kipling, R. 1987. *Life's Handicap*. Oxford University Press.

Klein, R. G. & Cruz-Uribe, K. 1984. *The Analysis of Animal Bones from Archeological Sites*. University of Chicago Press.

Knusel, C., Batt, C. M., Cook, G., Montgomery, J. M., Muldner, G., Ogden, A. R., Palmer, C., Stern, B., Todd, J. & Wilson, A. S. 2010. The St Bees Lady, Cumbria: an osteobiographical approach. *Medieval Archaeology* **54**: 275-317.

Kohn, G. C. (ed.) 1998. *The Wordsworth Encyclopedia of Plague and Pestilence*. Wordsworth Editions Ltd: Ware.

Koltes, J. E., Mishra, B. P., Kumar, D., Kataria, R. S., Totir, L. R., Fernando, R. L., Cobbold, R., Steffen, D., Coppieters, W., Georges, M. & Reecy, J. M. 2009. A nonsense mutation in cGMP-dependent type II protein kinase (PRKG2) causes dwarfism in American Angus cattle. *Proceedings of the National Academy of Sciences USA* **106** (46): 19250-19255.

Kron, G. 2002. Archaeozoological Evidence for the Productivity of Roman Livestock Farming. *Munstersche Beitrage zur Antiken Handelsgeschichte* **21**(2): 53-73.

Langdon, J. 1986. *Horses, Oxen and Technological Innovation*. Cambridge University Press.

Legge, A.J. 1981. Aspects of Cattle Husbandry. In R. Mercer (ed.) *Farming Practice in British Prehistory*. Edinburgh University Press: 169-181

Legge, A. J. & Rowley-Conwy, P. A. 1988. *Star Carr Revisited*. Birkbeck College: London

Legge, A. J. 1992. *Excavations at Grimes Graves, Norfolk, 1972-1976. Fascicule 4: Animals. Environment and the Bronze Age economy*. British Museum Press: London.

Legge, A. J. 2008. Livestock and Neolithic society at Hambledon Hill. In R. Mercer & F. Healey *Hambledon Hill, Dorset, England. Excavation and survey of a Neolithic monument complex and its surrounding landscape* Vol. 2. English Heritage: Swindon, 536-572.

Levitan, B. 1985. A methodology for recording the pathology and other anomalies of ungulate mandibles from archaeological sites. In N. R. J. Fieller, D. D. Gilbertson & N. G. A. Ralph (eds) *Palaeobiological Investigations: Research Design, Methods and Data Analysis*. BAR International Series **266**: Oxford, 41-54.

Lewine, E. 2005. *Death and the Sun*. Houghton Mifflin Company: Boston.

Lewis, M. 2002. Impact of industrialisation: comparative study of child health in four sites from medieval and post-medieval England (AD 850-1859). *American Journal of Physical Anthropology* **119** (3): 211-223.

Lister, A. M. 1989. Rapid dwarfing of red deer on Jersey in the Last Interglacial. *Nature* **342**: 539-542.

Longnon, J. & Cazelles, R. (eds) 1989. *Les Très Riches Heures du Duc de Berry*. Thames & Hudson: London.

Lucas, A. T. 1989. *Cattle in Ancient Ireland*. Boethius Press: Kilkenny.

MacDonald Fraser, G. 1974. *The Steel Bonnets: The Story of the Anglo-Scottish Border Reivers*. Pan Books Ltd: London.

Magnusson, M. & Palsson, H. (trans.) 1960. *Njal's Saga*. Penguin: Harmondsworth.

Malden, W. J. 1894 . The Influence of Dexter Cattle on Other Breeds. *Journal of the Royal Agricultural Society* Series 2, **30**: 531-540.

Maltby, M. 1979. *The Animal Bones from Exeter 1971-1975*. Exeter Archaeology Report **2**: Sheffield.

Markham, G. 1616. *Cheape and Good Husbandry for the Well-Ordering of all Beasts, and Fowles, and for the Generall Cure of their Diseases*. London

Matos, C. A. P., Carolino, N., Bettencourt, C. M. V. & Gama, L. T. 2002. Genetic Variability for Calving Interval and Growth Traits in Mertolenga Cattle. *7th World Congress on Genetics Applied to Livestock Production.* Montpellier

McCarthy, M. 2002. The Archaeology of Roman Non-Military Sites. In C. Brooks, R. Daniels & A. Harding (eds) *Past, Present and Future: The Archaeology of Northern England.* Architectural and Archaeological Society of Durham and Northumberland Research Report **5**, 105-111.

McCormick, F. 1992. Early Faunal Evidence for Dairying. *Oxford Journal of Archaeology* **11** (2): 201-209.

McHardy, S. 2004. *School of the Moon*. Birlinn Ltd: Edinburgh.

Mead, W. E. 1931. *The English Medieval Feast*. George Allen & Unwin Ltd: London.

Mead, S. W., Gregory, P. W. & Regan, W. M. 1946. A Recurrent Mutation of Dominant Achondroplasia in Cattle. *Journal of Heredity* **XXXVII**: 183-188.

Mellaart, J. 1975. *The Neolithic of the Near East*. Thames & Hudson: London.

Middleton, C. no date. *Supplying and Preparing Food to the Military: What was happening at Bainbridge Fort?* Archive Report for Tyne & Wear Museum Service.

Minton, J. G. 2002. *Agrarian Archives: A Thousand Years of Records*. History of Education Project: Durham.

Minwel Tibbott, S. 1985-6. Liberality and Hospitality. Food as Communication in Wales. *Folk Life* **24**: 32-51.

Minwel Tibbott, S. 1995-96. Cheese-Making in Glamorgan. *Folk Life* **34**: 64-79.

Moffat, J. 2004. *Down on the Funny Farm*. Bantam: London.

Morley, A. 1950. *Dairy Farmers Encyclopedia*. Right Way Books: Kingswood.

Morton Boyd, J. & Jewell, P. A. 1974. The Soay Sheep and their Environment: a Synthesis. In P. A. Jewell, C. Milner & J. Morton Boyd (eds) *Island Survivors: The Ecology of the Soay Sheep of St Kilda.* Athlone Press: London, 360-373.

Mourant, A. E. & Zeuner F. E. (eds) 1963. *Man and Cattle*. Royal Anthropological Institute Occasional Paper **18**.

Mukasa-Mugerwa, E. 1989. *A review of reproductive performance of female Bos Indicus (Zebu) cattle.* Addis Ababa: International Livestock Centre for Africa Monograph 6.

Mulville, J., Bond, J. & Craig, O. 2005. The white stuff, milking in the Outer Scottish Isles. In J. Mulville & A. Outram (eds) *The Zooarchaeology of Fats, Oils, Milk and Dairying.* Oxbow Books: Oxford, 167-182.

Newfield, T. P. 2009. A Cattle Panzootic in Early Fourteenth-Century Europe. *Agricultural History Review* **57** (2): 155–190.

Noddle, B. 1983. Appendix 4: Animal Bone from Knap of Howar. In A. Ritchie Excavation of a Neolithic farmstead at Knap of Howar, Papa Westray, Orkney. *Proceedings of the Society of Antiquaries of Scotland* **113**: 92-100.

Noddle, B. 1989. Cattle and Sheep in Britain and Northern Europe up to the Atlantic Period: A Personal Viewpoint. In A. Milles, D. Williams & N. Gardner (Eds) *The Beginnings of Agriculture*. BAR International Series **496**: 185-6.

Noddle, B. 1999. Bone defects in joint surfaces of intensively farmed livestock. In S. Anderson (ed.) *Current and Recent Research in Osteoarchaeology **2***. Oxbow Books: Oxford, 1-3.

O'Connor, T. P. 1982. *Animal Bones from Flaxengate, Lincoln c. 870-1500*. The Archaeology of Lincoln, **XVIII**-1: London.

O'Connor, T. P. 2000. *The Archaeology of Animal Bones*. Sutton Publishing Ltd: Stroud.

O'Connor, T. P. 2003. *The Analysis of Urban Animal Bone Assemblages: A Handbook for Archaeologists*. The Archaeology of York Principles and Methods **19/2**: York

O'Connor 2008a. On the differential diagnosis of arthropathy in bovids. In G. Grupe, G. McGlynn and J. Peters (eds) Limping Together Through the Ages. Joint afflictions and bone infections. *Documenta Archaeobiologae* **6**. Rahden: Verlag Marie Leidorf, 165-186.

O'Connor, T. P. 2008b. Review of "Food in Medieval England. Diet and Nutrition." *Environmental Archaeology* **13** (1): 89-90.

O'Connor, T. P. 2010. Livestock and deadstock in early medieval Europe from the North Sea to the Baltic. *Environmental Archaeology* **15** (1): 1-15.

Ohtaishi, N. 1972. A Case of Congenital Absence of the Lower Second Premolars in Cattle and a Phylogenetic Consideration of its Origin. *Japanese Journal of Veterinary Research* **20**: 7-12.

OMAFRA 2006. *Beef Bull Fertility*. Factsheet **410/20**. Ministry of Agriculture, Food and Rural Affairs. Ontario.

Orde, A. 2004. The Culleys and Farm Management. *Northern History* **XLI** (2): 327-338.

Oschinsky, D. 1971. *Walter of Henley and other Treatises on Estate Management and Accounting.* Clarendon Press: Oxford.

O'Sullivan, D. & Young R. 1991. The early medieval settlement at Green Shiel, Northumberland. *Archaeologia Aeliana 5th Series* **19**: 55-69.

Ozgul, A., Tuljapurkar, S., Benton, T. G., Pemberton, J. M., Clutton-Brock, T. H. & Coulson, T. 2009. The Dynamics of Phenotypic Change and the Shrinking Sheep of St. Kilda. *Science* **325**, 464-467.

Palin, M. 2004. *Himalaya*. Weidenfeld & Nicolson: London.

Pappa, M., Halstead, P., Kotsakis, K. & Urem-Kotsou, D. 2004. Evidence for Large-scale Feasting at Late Neolithic Makriyalos, Northern Greece. In P. Halstead & J. C. Barrett (eds) *Food, Cuisine and Society in Prehistoric Greece*. Oxbow Books: Oxford, 16-44.

Paston-Williams, S. 1993. *The Art of Dining*. National Trust: London.

Payne, S. 1973. Kill-off patterns in sheep and goats: the mandibles from Aşvan Kale. *Anatolian Studies* **23**: 281-303.

Payne, S. 2006. Old English yogurt. *British Archaeology* Nov-Dec: 54.

Pérez-Higuera, T. 1998. *The Art of Time: Medieval Calendars and the Zodiac*. Weidenfield & Nicolson: London

Perren, R. 1978. *The Meat Trade in Britain 1840-1914*. Routledge & Kegan Paul: London.

Persson, Y, Söderquist, L and Ekman, S. 2007. Joint disorder; a contributory cause to reproductive failure in beef bulls? *Acta Veterinaria Scandinavica* **49**: 31.

Piggott, S. 1962. Heads and hoofs. *Antiquity* **XXXVI**: 110-18.

Plusquellec, P. & Bouisson, M. 2001. Behavioural characteristics of two dairy breeds of cows selected (Herens) or not (Brune des Alpes) for fighting and dominance ability. *Applied Animal Behavioural Science* **72** (1): 1-21.

Power, E. 1928. *The Goodman of Paris*. Routledge: London.

Pringle, R. O. 1872. A Review of Irish Agriculture, chiefly with Reference to the Production of Live Stock. *Journal of the Royal Agricultural Society of England Second Series* **8**: 1-60.

Proud, K. & Butler, R. 1985. *The Origins and Early Development of Shorthorn Cattle*. Discovery Design & Print Ltd: Brafferton

Prummel, W. 1987. Atlas for identification of foetal skeletal elements of Cattle, Horse, Sheep and Pig Part 1. *Archaeozoologia* **1** (1): 23-30

Prummel, W. 1989. Appendix to Atlas for identification of foetal skeletal remains of Cattle, Horse, Sheep and Pig. *Archaeozoologia* **III** (1,2): 71-78.

Pryor, F. 1998. *Farmers in Prehistoric Britain*. Tempus: Stroud.

Rackham, D.J. 1986. A Comparison of Age Determination from the Mandibular Dentition of an Archaeological Sample of Cattle. In E. Cruwys & R. A. Foley (eds), *Teeth and Anthropology*. BAR International Series **291**: Oxford, 149-168.

Rackham, D. J. 1987a. Assessing the relative frequencies of species by the application of a stochastic model to a computerised database of fossil or archaeological skeletal material. In Wijngaarden-Bakker, L. van (Ed) *Data Management of Archaeological Assemblages.* PACT, 185-192.

Rackham, D. J. 1987b. The Animal Bone. In D. H. Heslop *The Excavation of an Iron Age Settlement at Thorpe Thewles, Cleveland, 1980-82.* CBA Research Report **65**: London, 99-109.

Rackham, D. J. 2008. The Animal Bone. In H. E. M. Cool & D. Mason (eds) *Roman Piercebridge*. Architectural and Archaeological Society of Durham and Northumberland Research Report **7**: 271-281.

Rackham, D. J. Unpubl. *The use of diagnostic zones for considerations of quantification, preservation, level of fragmentation, skeletal selection and butchery.*

Rackham, D. J. & Gidney, L. J. 2008. The Animal Bone. In H. E. M. Cool & D. Mason (eds) *Roman Piercebridge*. Architectural and Archaeological Society of Durham and Northumberland Research Report **7**: D12.1-119.

Raffald, E. 1970 facsimile of 1782 8th edn. *The Experienced English Housekeeper*. E & W Books: London.

Railton, M. 2009. Archaeological Investigation of the Remains of a Medieval Vaccary at Gatesgarth Farm, Buttermere. *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society* 3rd Series **IX**, 57-67.

Rasby, R. J., Rush, I. G. & Stock, R. 1994. *Wintering and Backgrounding Beef Calves.* NebGuide **G4-1228**. University of Nebraska-Lincoln Extension.

Rayner, L. 1999. *An examination of the cattle metapodials from the Roman fort at Vindolanda*. Undergraduate dissertation, Department of Archaeology, Durham University.

Redon, O., Sabban, F. and Serventi, S. 1998. *The Medieval Kitchen: Recipes from France and Italy*. University of Chicago Press: Chicago.

Reed, R. 1972. *Ancient Skins, Parchments and Leathers*. Seminar Press: London.

Reynolds, P. J. 1976. *Farming in the Iron Age*. Cambridge University Press.

Rhys, M. 1936. *Ministers' Accounts for West Wales 1277-1306. Part I.* Cymmrodorion Record Series **XIII**.

Richardson, C., Jones, P. C., Barnard, V., Hebert, C.N., Terlecki, S. & Wijeratne, W. V. S. 1990. Estimation of the developmental age of the bovine fetus and newborn calf. *Veterinary Record* **126**: 279-284.

Richter, J. 1982. Faunal Remains from Ulkestrup Lyng Ost Hunters Dwellingplace. In A. K. Andersen & S. Jorgensen *Maglemose hytterne ved Ulkestrup Lyng*. Copenhagen: 141-176.

Rider Haggard, H. 1899. *A Farmer's Year*. Longmans, Green & Co.: London.

Rimas, A. & Fraser, E. D. G. 2009. *Beef*. Harper: London.

Rippon, S. 2004. Making the Most of a Bad Situation? Glastonbury Abbey, Meare, and the Medieval Exploitation of Wetland Resources in the Somerset Levels. *Medieval Archaeology* **48**: 91-130.

Rixson, R. 2000. *The History of Meat Trading*. Nottingham University Press: Nottingham.

Robertson, U. A. 1994. The Supply and Sale of Milk in Nineteenth-Century Edinburgh. In P. Lysaght (ed.), *Milk and Milk Products from Medieval to Modern Times*. Proceedings of the Ninth International Conference on Ethnonological Food Research. Canongate Press: Edinburgh, 64-70.

Rogers, A. 2008. *Roman towns as meaning laden places: reconceptualising the growth and decline of towns in Roman Britain*. PhD thesis: Durham University.

Rogers, B. 2004. *Beef and Liberty.* Vintage: London.

Rowley-Conwy, P. & Owen, A. C. 2011. Grooved Ware Feasting in Yorkshire: Late Neolithic Animal Consumption at Rudston Wold. *Oxford Journal of Archaeology* **30** (4) 325-367.

Rutherford, B. 2005. *My Love Affair with the Dexter*. Triple D Books: Wagga Wagga.

Ryder, M. L. 1983. *Sheep and Man.* Duckworth: London.

Salter, D. 2001. *Holy and Noble Beasts*. D.S. Brewer: Cambridge.

Schloeth, R. 1961. Das Sozialleben des Camargue-Rindes. *Zeitschrift fur Tierpsychologie* **18**: 574-627.

Schmid, E. 1972. *Atlas of Animal Bones*. Elsevier Publishing Co.: London

Schofield, V. 1995. Overseas News: Visit to Germany. *The Dexter Cattle Society Bulletin* **129**: 10-12.

Schwabe, A. E. & Hall, S. J. G. 1989. Dystocia in nine British breeds of cattle and its relationship to the dimensions of the dam and calf. *Veterinary Record* **125**, 636-639.

Scott, S. E. 2000. *The Animal Bones from Green Shiel, Lindisfarne*. MSc Dissertation, Department of Archaeology, University of Durham.

Scott, W. 1931. *Minstrelsy of the Scottish Border*. Harrap: London.

Scully, T. 1995. *The Art of Cookery in the Middle Ages.* The Boydell Press. Woodbridge.

Selk, G. 2008. *Fall Born Calves Have Lighter Birth Weights*. Oklahoma State University Animal Science Research Report.

Serjeantson, D., Waldron, T, & McCracken, S. 1986. Veal and calfskin in eighteenth century Kingston? *The London Archaeologist* **5** (9): 227-232

Shahin, K. A., Berg, R. T. & Price, M. A. 1992. The effect of breed-type and castration on bone growth and distribution in cattle. *Reproduction Nutrition Development* **32**: 429-440.

Sheringham, J. G. T. 1982. Bullocks with Horns as Long as Their Ears. *The Bulletin of the Board of Celtic Studies* **XXIX** (IV) 691-708.

Sherratt, A. G. 1981. Plough and Pastoralism: aspects of the Secondary Products Revolution. In I. Hodder, G. Isaac & N. Hammond (eds) *Pattern of the Past*. Cambridge University Press: Cambridge, 261-306.

Silver, I. A. 1969. The ageing of domestic animals. In D. Brothwell & E. Higgs (eds) *Science in Archaeology*. Thames & Hudson: London, 283-302.

Skeat, W. W. (ed.) 1965. *Piers the Plowman*. Clarendon Press: Oxford.

Smith, A. F. 2000. The Origins of the New York Dairy Industry. In H. Walker (ed.) *Milk: Beyond the Dairy. Proceedings of the Oxford Symposium on Food and Cookery 1999*. Prospect Books: Totnes, 315-329.

Smith, E. 1994 facsimile of 1758. *The Compleat Housewife: or, Accomplished Gentlewoman's Companion.* Studio Editions Ltd: London.

Smith, F. D. & Wilcox, B. 1951. *The Family Farmer*. The Country Book Club: London.

Spargo, D. (ed.) 1988. *This Land is Our Land*. Royal Agricultural Society of England: London.

Spooner, R. L., Bradley, J. S. & Young, G. B. 1975. Genetics and disease in domestic animals with particular reference to dairy cattle. *Veterinary Record* **97**: 125-30.

Spry, C. 1972. *The Constance Spry Cookery Book*. Pan: London.

Stallibrass, S. 1983. A bifid thoracic vertebral spine from a bovine in the Roman Fenland. *Journal of Archaeological Science* **10**: 265-6.

Stallibrass, S. 1993. *Post-Medieval Cattle Burials from St Giles by Brompton Bridge, North Yorkshire.* Ancient Monuments Laboratory Report **94/93**.

Sten, S. 2004. *Bovine Teeth in Age Assessment, from Medieval Cattle to Belgian Blue: Methodology, Possibilities and Limitations*. Karolinska University Press: Stockholm.

Stokes, P. R. G. & Huntley, J. P. 1998. *Animal Bone from Market Place, Masham* Durham Environmental Archaeology Report **57/98**.

Stoppard-Rose, N. 2013. *Man's Forgotten Friend: A History of the Ox*. Made in the USA: Charleston.

Straiton, E. 1964. *TV Vet Book for Stock Farmers*. Farming Press Ltd: Ipswich.

Straiton, E. 1972. *TV Vet Sheep Book*. Farming Press Ltd: Ipswich.

Straiton, E. 1988. *Calving the Cow and Care of the Calf*. Farming Press Ltd: Ipswich.

Swanton, M. (trans.) 1993. *Anglo-Saxon Prose*. J. M. Dent: London.

Sykes, N. J. 2006. From *Cu* and *Sceap* to *Beffe* and *Motton*. In C. M. Woolgar, D. Serjeantson & T. Waldron (eds) *Food in Medieval England*. Oxford University Press: 56-71.

Sykes, N. J. 2007. *The Norman Conquest: A Zooarchaeological Perspective*. BAR International Series **1656**: Oxford.

Sykes, N. & Symmons, R. 2007. Sexing Cattle Horn Cores: Problems and Progress. *International Journal of Osteoarchaeology* **17**: 514-523.

Tchernov, E. 1993. From sedentism to domestication – a preliminary review for the southern Levant. In A. Clason, S. Payne & H.-P. Uerpmann (Eds) *Skeletons in her Cupboard*. Oxbow Monograph **34**: Oxford, 189-234.

Teichert, M. 1993. Size and utilisation of the most important domesticated animals in Central Europe from the beginning of domestication until the late Middle Ages. In A. Clason, S. Payne & H.-P. Uerpmann (Eds) *Skeletons in her Cupboard*. Oxbow Monograph **34**: Oxford, 235-8.

Telldahl, Y. 2005. Can palaeopathology be used as evidence for draught animals? In J. Davies, M. Fabiš, I. Mainland, M. Richards and R. Thomas (Eds) *Diet and Health in Past Animal Populations*. Oxbow Books: Oxford, 63-67.

Tenucci, M., Vitale, A. F., Papini, M. & Lovari, S. 1986. Social behaviour of the calves of semi-wild Maremma cattle, *Bos primigenius taurus. Applied Animal Behaviour Science* **16** (3): 217-231.

Tenucci, M. & Vitale, A. F. 1991. Grandsons of Aurochs. *The Ark* **XVIII** (7): 248-50.

Thear, K. 1983. *Home Dairying*. Batsford: London

Thingnæs, S. 2010. Textile Craftmanship in the Norwegian Migration Period. In E. Andersson Strand, M. Gleba, U. Mannering, C. Munkholt & M. Ringgaard (eds). *North European Symposium for Archaeological Textiles X*. Oxbow Books: Oxford, 235-239.

Thomas, R. and Mainland, I. 2005. Introduction: animal diet and health – current perspectives and future directions. In J. Davies, M. Fabiš, I. Mainland, M. Richards & R. Thomas (Eds) *Diet and Health in Past Animal Populations*. Oxbow Books: Oxford, 1-7.

Thomas, R. & Johannsen, N. 2011. Articular depressions in domestic cattle phalanges and their archaeological relevance. *International Journal of Paleopathology* **1**: 43-54.

Thompson, M. 2005. Medieval dairying in England: prescription, practice and performance. In J. Mulville & A. K. Outram (eds) *The Zooarchaeology of Fats, Oils, Milk and Dairying*. Oxbow Books: Oxford: 132-141.

Trow-Smith, R. 1957. *A History of British Livestock Husbandry to 1700*. Routledge & Kegan Paul: London.

Trusler, J. 1791. *The Honours of the Table*, Dublin.

Trut, L. N. 1999. Early Canid Domestication: The Farm-Fox Experiment. *American Scientist* **87**: 160-169.

Tyldesley, J. 2007. *Egyptian Games and Sports*. Shire Publications Ltd: Princes Risborough.

Tyler, W. S., Julian, L. M., McFarland, L. Z., Evans, H. E. & Gregory, P. W. 1961. Bovine Achondroplasia. III. Standards of Metacarpal Indexes for Achondroplastic, Brachycephalic Dwarfs and Controls. *American Journal of Veterinary Research* **22**: 693-7.

Usha, A. P., Lester, D. H. and Williams, J. L. 1997. Dwarfism in Dexter cattle is not caused by the mutations in FGFR3 responsible for achondroplasia in humans. *Animal Genetics* **28** (1): 55-7.

van Vlierbergen, B., Chiers, K., Hoegaerts, M., Everaert, D. and Ducatelle, R. 2007. Hip dysplasia-like lesions in a Belgian Blue cow. *Veterinary Record* **160**: 910-12.

van Vuure, C. 2005. *Retracing the aurochs: history, morphology and ecology of an extinct wild ox.* Sofia: Pensoft.

Vigne, J.-D. & Helmer, D. 2007. Was milk a "secondary product" in the Old World Neolithisation process? Its role in the domestication of cattle, sheep and goats. *Anthropozoologia* **42** (2), 9-40.

Wade-Evans, A. W. 1909. *Welsh Medieval Law*. Clarendon Press: Oxford.

Ward, R. & Mulville, J. 2010. *Osteochondrosis in Archaeological Cattle*. Poster presented at the fourth ICAZ Animal Palaeopathology Working Group Conference

Watts, M. 1999. *Working Oxen*. Shire Publications: Princes Risborough.

Watson, A. 2007. *Religious Acculturation and Assimilation in Belgic Gaul and Aquitania from the Roman Conquest until the End of the Second Century CE*. Oxford: BAR International Series **1624**.

Watson, C. 2007. *Lameness in Cattle*. Crowood Press Ltd: Ramsbury.

Wells, C. 1992. *The Roman Empire*. Fontana: London.

West, B. 1990 for 1988. A tale of two innominates. *Circaea* **6** (2), 107-114.

Weston D. A. 2008. Investigating the Specificity of Periosteal Reactions in Pathology Museum Specimens. *American Journal of Physical Anthropology* **137**: 48-59.

Wheaton-Smith, Major C. 1963. Cattle Breeds – A Study in Progressive Hybridization. In A. E. Mourant & F. E.Zeuner (eds) *Man and Cattle*. Royal Anthropological Institute Occasional Paper **18**.

White, K. D. 1978. *Country Life in Classical Times*. Book Club Associates: London.

Whitehead, G. K. 1953. *The Ancient White Cattle of Britain and their Descendants*. Faber & Faber Ltd: London.

Whitlock, R. 1977. *Bulls Through the Ages*. Lutterworth Press: Guildford.

Whittaker, C. R. 1988. Introduction. In C. R. Whittaker (ed) *Pastoral Economies in Classical Antiquity*. Cambridge Philological Society. Supplementary Volume **14**: 1-5.

Wiener, P., Burton, D. & Williams, J. L. 2004. Breed relationships and definition in British cattle: a genetic analysis. *Heredity* **93**, 597-602.

Wijngaarden-Bakker, L. H. van 1997. Aurochs and Heck Cattle. *Anthropozoologica* **25-26**: 193-199.

Wileman, J. 2005. *Hide and Seek: The Archaeology of Childhood*. Tempus: Stroud.

Williamson, H. 1942. *The Story of a Norfolk Farm*. Readers Union: London.

Williamson, T. 2007. *Rabbits, Warrens and Archaeology*. Tempus: Stroud.

Winchester, A. J. L. 2000. *The Harvest of the Hills: Rural Life in Northern England and the Scottish Borders 1400-1700*. Edinburgh University Press.

Winchester, A. J. L. 2003. Demesne Livestock Farming in the Lake District. The Vaccary at Gatesgarth, Buttermere in the Later Thirteenth Century. *Transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society* 3rd Series **III**: 109-118.

Winship, L. 1996. *Analysis of the cattle metapodials at the Arbeia Roman Fort, South Shields*. Undergraduate dissertation, Department of Archaeology, Durham University.

Woolgar, C. M. 2006. Meat and Dairy Products in Late Medieval England. In C. M. Woolgar, D. Serjeantson and T. Waldron (eds) *Food in Medieval England*. Oxford University Press. 88-101.

Wright, S. 1978. The Relation of Livestock Breeding to Theories of Evolution. *Journal of Animal Science* **46**: 1192-1200.

Young, A. 1973 facs. of 1771. *The Farmer's Kalendar*. EP Publishing Ltd: East Ardsley.

Young, A. 1796. On the Advantages of Cottagers Renting Land. *Annals of Agriculture* **XXVI**: 227-245

Young, A. 1797. Observations on Raising Beasts to a High Degree of Fatness and of the Increase of Horses. *Annals of Agriculture* **XXVIII**: 380-386.

Young, A. 1797. On the Size of Cattle. *Annals of Agriculture* **XXVIII**: 604-608.

Ytrehus, B., Carlson, C. S. & Ekman, S. 2007. Etiology and Pathogenesis of Osteochondrosis. *Veterinary Pathology* **44**: 429-448.

Zalkin, V. I. 1960. Metapodial variation and its significance for the study of antient (*sic*) horned cattle. *Bull. D. Mosk. Ges. D. Nat'Forscher. Abt. Biol*. **65**. 109-126. (Russian with English Summary).

Table 2: 1 Dexter Bulls: Calves sired

Aiskew Juglans Nigra 16/3/1987 - 29/9/2000

	Homebred		Hired/Herd Book		Totals			No of herds	Visiting cows
	Heifer	Bull	Heifer	Bull	Heifer	Bull	All		births not notified
1989			2		2		2	1	
1990	1		4	3	5	3	8	5	2
1991		2	8	4	8	6	14	7	3
1992			3	2	3	2	4	3	1
1993	1	1	1		2	1	3	2	
1994			4	2	4	2	5	2	
1995	3			1	3	1	4	2	
1996	4	1		1	4	2	5	2	
1997		2	2	2	2	4	6	2	
1998	3	4		1	3	5	8	2	
1999			3	1	3	1	4	1	
2000			2	3	2	3	5	1	
Totals	12	10	29	20	41	30	71		

Table 2: 1 cont.

Dalmuir Cyclone 28/2/90 - 15/6/98

	Homebred		Hired/Herd Book		Total			No of herds
	Heifer	Bull	Heifer	Bull	Heifer	Bull	All	
1993	2	1			2	1	3	1
1994	2	3			2	3	5	1
1995			3	2	3	2	5	1
1996			8	2	8	2	10	4
1997			2	4	2	4	6	4
1998			1	3	1	3	4	4
Totals	4	4	14	11	18	15	33	

Table 2: 2. Scrotal Circumference Data

Minimum Recommended Scrotal Circumferences (cm). After OMAFRA 2006				
AGE (months)	**BREED**			
	Simmental	**Angus Charolais Maine Anjou**	**Hereford Shorthorn**	**Limousin Blonde d'Aquitaine**
12–24	33	32	31	30
15–20	35	34	33	32
21–30	36	35	34	33
>30	37	36	35	34

Young Dexter Bulls, South Africa. After Annandale 2007

Bull	**A**	**B**	**C**	**D**	**E**	**F**
Age, months	**14**	**16**	**15**	**13**	**17**	**15**
Weight, kg	**210**	**348**	**212**	**255**	**248**	**206**
Scrotal Circumference, cm	**29**	**27**	**31**	**32**	**30**	**26**

Dexter bulls available on A.I., Australia. After dexter.une.edu.au

Bull									
12-24 months									
15-20 months				**x**		**x**			
21-30 months									
>30 months	**x**	**x**	**x**		**x**		**x**	**x**	**X**
Scrotal Circumference, cm	**39**	**38.5**	**36**	**27**	**39**	**32**	**38.5**	**35**	**34**
Hip height				**105**	**121.5**	**115**	**116**	**119.5**	
Withers height		**119**	**132**						

Bull										
12-24 months	**x**									
15-20 months									**x**	
21-30 months		**x**	**x**				**x**			
>30 months				**x**	**x**	**x**		**x**		**X**
Scrotal Circumference, cm	**28.6**	**36**	**34**	**32**	**31**	**39**	**22**	**31**	**34.5**	**33**
Hip height		**112**					**120**		**116**	**116**
Withers height	**102**		**110**							

Bull									
12-24 months									
15-20 months									
21-30 months	**x**								
>30 months		**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
Scrotal Circumference, cm	**31.5**	**37.5**	**33.5**	**37**	**33**	**38**	**39**	**33**	**37**
Hip height			**117**	**112**	**112**		**117**		**117**
Withers height	**106**								

Bull									
12-24 months									
15-20 months									
21-30 months					**x**			**x**	**x**
>30 months	**x**	**x**	**x**	**x**		**x**	**x**		
Scrotal Circumference, cm	**36.5**	**35**	**40**	**34**	**34**	**33**	**40**	**32**	**31**
Hip height		**118**	**115**			**109**			**112**
Withers height					**106.5**			**109**	

Zanfara and Broomcroft herds

English Bulls			
>30 months	**x**	**x**	**x**
Scrotal Circumference, cm	**34**	**34**	**42**

Summary Data Dexter Scrotal circumference
Age 12-24 months
N=3, Range 28.6-32cm, Mean 30cm
Age 15-20 months
N=7, Range 26-34.5cm, Mean 30cm
Age 21-30 months
N=7, Range 22-36cm, Mean 31.5cm
Age >30 months
N=29, Range 31-42cm, Mean 36cm

Hip Height age >30 months
N=13, Range 112-132cm, Mean 118cm

Table 2: 3. Dexter Bulls: Mandible Wear Stages (after Grant 1982)

	P4	M1	M2	M3	MWS
Left	J	O	M	M	
Right	J	O	M	L	
Left		19	17	17	53
Right		19	17	16	52

Cyclone	P4	M1	M2	M3	MWS
Left	F	M	K	G	
Right	F	M	K	G	
Left		17	15	12	44
Right		17	15	12	44

Hawick Aurochs	P4	M1	M2	M3	MWS
M3 lost		K	J	H or G?	
Estimated wear stage		15	14	13 or 12?	41 or 42?

Chillingham c. 1980	P4	M1	M2	M3	MWS
Left	F	L	K	K	
Right	F	K	K	K	
Left		16	15	15	46
Right		15	15	15	45

Chillingham 1947	P4	M1	M2	M3	MWS
Left		K	K	J	
Right		K	K	J	
Left		15	15	14	44
Right		15	15	14	44

Comet	P4	M1	M2	M3	MWS
Left		L	K	J	
Left		16	15	14	45

Halle H820	P4	M1	M2	M3	MWS
Shorthorn 6years	G	L	K	K	
		16	15	15	46

Halle H734	P4	M1	M2	M3	MWS
Hollander 6 years 10 months	F	K	J	J	
		15	14	14	43

Halle H1083	P4	M1	M2	M3	MWS
Podolisches Steppenrind >13 years	G	N	M	M	
		18	17	17	52

Table 2: 4 Distribution of Osteochondrosis Depressions in Dexter Bulls

X = present
& = corresponding marks on articulating joint surfaces

	Juglans Nigra	Cyclone
Mandibular hinge		
Scapula glenoid	&	
Humerus proximal	&	
Humerus distal	&	&
Radius proximal	&	&
Radius distal	X	X
Carpals		
Metacarpal proximal	X	X
Metacarpal distal		
Acetabulum		
Femur proximal		
Femur distal		
Patella		
Tibia proximal		
Tibia distal	&	
Astragalus	&	X
Calcaneum		
Metatarsal proximal		
Metatarsal distal		
	No. of phalanges	
Phalanx 1 proximal	5	5
Phalanx 1 distal	4	7
Phalanx 2 proximal		
Phalanx 2 distal	2	7
Phalanx 3	4	8

Table 2:5a. Greatest Length Measurements (mm)

	Juglans	Nigra	Cyclone	Cyclone	Chillingham	Chillingham
	L	R	L	R	L	R
Scapula (GLP)	75.7	77.4	64.9	63	66.7	65.1
Humerus	298	300	272	271	285	283
Metacarpal	180	181	154	151		182
Femur	369	366	323	325	357	355
Tibia	321	323	298	300	331	327
Metatarsal	210	208	174	176	213	210

Table 2:5b. Estimated Withers Heights from above measurements, using factors of Matolcsi (Driesch & Boessneck 1974, 336)

	Juglans	Nigra	Cyclone	Cyclone	Chillingham	Chillingham
	L	R	L	R	L	R
Humerus	1.23m	1.24m	1.12m	1.12m	1.17m	1.17m
Femur	1.19m	1.18m	1.04m	1.04m	1.15	1.14m
Tibia	1.10m	1.11m	1.02m	1.03m	1.14m	1.12m

Table 2:5c. Estimated Withers Heights from metapodial measurements, using average of factors for cows and steers given by Boessneck (B), Zalkin (Z), Fock (F) and Matolcsi (M) (Driesch & Boessneck 1974, 336)

	Juglans	Nigra	Cyclone	Cyclone	Chillingham	Chillingham
	L	R	L	R	L	R
Metacarpal (B)	1.17m	1.17m	1.00m	0.98m		1.18m
Metatarsal (B)	1.22m	1.20m	1.01m	1.02m	1.23m	1.22m
Metacarpal (Z)	1.11m	1.10m	0.94m	0.92m		1.11m
Metatarsal (Z)	1.14m	1.13m	0.95m	0.96m	1.16m	1.14m
Metacarpal (F)	1.12m	1.13m	0.96m	0.94m		1.13m
Metatarsal (F)	1.14m	1.13m	0.94m	0.95m	1.16m	1.14m
Metacarpal (M)	1.11m	1.12m	0.95m	0.93m		1.12m
Metatarsal (M)	1.14m	1.13m	0.94m	0.95m	1.16m	1.14m

Table 2:5d. Estimated Withers Heights from metapodial measurements, using factors for entire males (Driesch & Boessneck 1974, 338)

	Juglans	Nigra	Cyclone	Cyclone	Chillingham	Chillingham
	L	R	L	R	L	R
Metacarpal	1.13m	1.14m	0.97m	0.95m		1.14m
Metatarsal	1.17m	1.16m	0.97m	0.98m	1.19m	1.17m

Table 3:1. Values of Cattle in Welsh Law (after Wade-Evans 1909, 217)

	She calf	He calf
1st year		
birth to calends of December	six pence	six pence
2nd year		
until calends of February	eight pence	eight pence
until calends of May	ten pence	ten pence
August	twelve pence	twelve pence
until calends of December	fourteen pence	fourteen pence
3rd year		
until calends of February	sixteen pence	sixteen pence
until calends of May	eighteen pence	eighteen pence
until August	twenty pence	twenty pence
increase for the season	two pence	
calf bearing	four pence	
until calends of December	twenty-six pence	twenty two pence
4th year		
until calends of February	twenty-eight pence	twenty-four pence
if yoked, increase of		four pence
if can plough on 9th Feb		teithi sixteen pence
increase for the season		two pence
until calends of May	thirty pence	forty-six pence
9th May milk in each teat & calf	teithi sixteen pence	
increase for the season	two pence	
until August	forty-eight pence	forty-eight pence
until calends of December	fifty pence	fifty pence
5th year		
until calends of February	fifty-two pence	fifty-two pence
yoked for 2nd work year		four pence
increase for the season	two pence	two pence
second calf bearing	four pence	
Final value	three score pence	three score pence

Table 3: 2. Summary of Dexter Calf Weights

Dexter Herd Book Birth Weights	N	Mean	Range	Standard Deviation
All calves	553	21kg	6-41kg	4kg
Bull calves	266	22kg	6-41kg	4.4kg
Heifer calves	287	20kg	8-32kg	3.7kg

Table 3: 3 Summary of Knotting herd calf weights

Knotting Herd Birth Weights	N	Mean	Range	Standard Deviation
All calves	253	22kg	9-33kg	3.7kg
Bull calves	155	22kg	14-33kg	3.4kg
Heifer calves	95	21kg	9-28kg	3.6kg
Grand Total of all Calves recorded	892	21kg	6-41kg	4kg

Table 3: 4. Knotting herd: calf birth weights by month

Month	Number of births	Mean birth weight (kgs)	Range of birth weights (kgs)
January	9	20.9	16-27
February	12	23.2	17-33
March	19	22	16-28.5
April	19	21	16-25.5
May	24	21.4	13.5-27
June	36	21.8	16-28
July	31	22	16-29.5
August	33	22.7	9-29.5
Sept	30	21.9	11-28
October	19	22	13.5-29.5
November	8	21.4	13.5-25.5
December	9	19.4	13.5-24.5

Table 3: 5. Summary of Harron herd calf weights

Harron Herd 1984-2000	N	Mean	Range	Standard Deviation
All calves	161	21.5kg	9-30kg	3kg
Bull calves	86	22kg	14-30kg	3kg
Heifer calves	75	21kg	9-30kg	3kg

Table 3: 6. Mean Lengths of Foetal Bones

Days gestation	100	140	160	180	220	260	280
Jersey radius	16mm	34mm	45mm	59mm	93mm	126mm	133mm
Sim/Fri radius	16mm	34mm	44mm	56mm	87mm	116mm	126mm
Jersey tibia	18mm	41mm	54mm	73mm	166mm	164mm	172mm
Jersey tibia 95% tolerance					108mm	155mm	159mm
Sim/Fri tibia	18mm	39mm	54mm	70mm	108mm	146mm	159mm

Table 3: 7. Lengths of calf bones: stillborn Dexters and archaeological finds from Lindisfarne.

	N	Mean	Range	Standard Deviation
Dexter radius	7	103mm	94-110mm	5mm
Lindisfarne radius	7	114mm	109-122mm	4mm
Dexter tibia	7	132mm	116-142mm	8mm

Table 3: 8 Newborn Dexter calf skeletons

Herd	Bull	Heifer	Bulldog
Vycanny	1	1	1 lost
Butterbox	1 lost	1 lost	
Zanfara	4 and 1 lost	1	1

Table 3: 9 Sucking calves reference skeletons

Natural mortalities, older than newborn

Name	Sex	Dam	Sire	Born	Died	Age	Skeleton
Gundrada	Heifer	Zanfara Tiggywinkle	Zanfara Orlando	23/02/2009	08/04/2009	6 weeks	partial
Tinkerbelle	Heifer	Jersey	Angus	c.22/2/96	06/05/1996	10 weeks	complete
Luke	Bull	Zanfara Rebecca	Zanfara Orlando	04/04/2010	08/07/2010	3 months	partial
Dozey	Bull	Zanfara Jaquetta	Dalmuir Cyclone	09/02/1994	25/07/1994	5 months	complete

Table 3: 10 Slaughter profile of Jersey calves

Name	Date entered herd	Age	Date slaughtered	Age at death
Monster Moo	6/3/93	1 week	5/7/93	4 months
Stuart	19/3/93	1 week	16/8/93	5 months
Edward	13/8/93	4 weeks	10/1/94	6 months
Victor	13/8/93	1 week	28/2/94	6 months

Table 3: 11 Young beef Dexters for whom some bones are extant

Animals killed for meat

Italic = parent in reference collection

Name	Sex	Dam	Sire	Born	Died	Age	Skeleton
Medlar	Bull	Zanfara Jaquinta	Weardale Didiscus	07/04/1997	24/11/1997	7 months	partial
Lorenzo	Bull	Zanfara Laurel	*Aiskew Juglans Nigra*	17/03/1997	08/02/1998	11 months	partial
Marmalade	Bull	Zanfara Jaquinta	Zanfara Quince	08/02/2000	11/02/2001	12 months	partial
Butterbox	Bull	*Templeton Chevette*	Statenboro Saprophyte	28/03/1986	08/06/1987	15 months	partial
Pyrite	Bull	Zanfara Laurelite	Zanfara Orlando	21/08/2008	15/11/2009	15 months	partial
Kaliph	Steer	Zanfara Rebekah	Zanfara Orlando	22/02/2009	18/04/2010	14 months	partial
Laurie	Bull	Zanfara Lauretta	Zanfara Quince	10/04/2001	15/09/2002	17 months	partial
Butterbox	Steer	Butterbox Dipper	Statenboro Saprophyte	21/03/1986	29/08/1987	17 months	partial
Parsnip	Steer	Vycanny Peachroots	Saltaire Finian	09/03/1990	04/09/1991	18 months	complete
Apicius	Bull	*Chalena 6th of Zelston*	*Aiskew Juglans Nigra*	23/02/1998	04/10/1999	20 months	partial
George	Bull	Zanfara Clarissa	Zanfara Quince	30/01/2000	26/09/2001	20 months	partial
Carrot	Steer	*Vycanny Kirstie*	Saltaire Pug	22/04/1990	02/08/1992	28 months	complete
Dusty	Heifer	Vycanny Mandy (Jersey X)	*Aiskew Juglans Nigra*	26/01/1990	17/01/1993	36 months	complete

Table 3: 12 Epiphysial fusion Dexter cull cohort 11-30 months.

One record for each beast

Epiphyses in Approximate Order of Fusion
Ages of fusion after Silver 1969

F = Fused, JF = Just Fused, U = Unfused

N = 11

Extant bones only

	U	JF	F	Marmalade
				Laurie
by 18 months				George
Scap tub		1	9	Lorenzo
Acet symph		5	3	Apicius
Prox rad			11	Carrot
Dist hum		8	2	Parsnip
				Bboxbull
by 2-3 years				Pyrite
Dist tib	11			Bboxsteer
				Kaliph
by 3.5-4 years				
Prox cal	10			
Prox fem	11			
Dist rad	11			
Prox hum	10			
Prox tib	11			
Dist fem	11			
Prox uln	11			

Table 3:13 Epiphysial fusion Jersey cross cull cohort 11-30 months.

One record for each beast (unless difference between sides)

Epiphyses in Approximate Order of Fusion
Ages of fusion after Silver 1969

F = Fused, JF = Just Fused, U = Unfused

Extant bones only

N = 4

	U	JF	F	Rufus
				Sienna
by 18 months				Thunder
Scap tub	1		2	Midas
Acet symph	3		1	
Prox rad	2	1	2	
Dist hum	1	1	1	
by 2-3 years				
Dist tib	4			
by 3.5-4 years				
Prox cal	4			
Prox fem	4			
Dist rad	4			
Prox hum	3			
Prox tib	3			
Dist fem	4			
Prox uln	4			

Table 3: 14. Distribution of osteochondrosis depressions in Dexter male cull cohort 6-30 months old

(S) = Short (NS) = non-short

X = present
n/a = not applicable, bone not extant

Sire	Didiscus		Quince		Quince Laurie (NS)		Quince George (S)		J. Nigra		J. Nigra Apicius (NS)		Pug		Finian		Saprophyte		Orlando		Saprophyte		Orlando Kaliph (NS)	
Name	Medlar (S)		Marmalade(NS)						Lorenzo (NS)				Carrot (S)		Parsnip (S)		Bboxbull(NS)		Pyrite (NS)		Bboxsteer(NS)			
	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R
Scapula glenoid	X	X			X	X	X	X	X	X	X	X	X	X	X	X	n/a	X	n/a	n/a	n/a	X		n/a
Humerus proximal						X				X			X				n/a	n/a						n/a
Humerus distal	X	X					X	X					X	X	X	X	n/a	n/a	X		X		X	
Radius proximal	X	X				X	X								X	X		n/a	X					
Radius distal	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	n/a			X	X	X	
Carpals	4	4		1			3	3			1		2	4	3	5	1`	n/a	1		1		1	1
Acetabulum																	n/a	n/a	n/a	n/a	n/a		n/a	n/a
Femur proximal																						n/a		n/a
Femur distal														X	X							n/a		n/a
Patella											X	X					n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Tibia proximal														X				n/a	n/a			n/a		n/a
Tibia distal													X						n/a			n/a		n/a
Astragalus	X	X			X		X	X					X	X	X	X	X	X	n/a			n/a		n/a
Calcaneum	X												X	X		X			n/a			n/a		n/a
Centroquartal	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	n/a	X		n/a	X	n/a

Table 3: 15. Distribution of osteochondrosis depressions in Jersey X male cull cohort 11-30 months

X = present
n/a = not applicable, bone not extant

Sire	Shorthorn		Aberdeen Angus		Aberdeen Angus		Shorthorn	
Name	Rufus		Sienna		Thunder		Midas	
	L	R	L	R	L	R	L	R
Scapula glenoid	n/a	n/a	X	X	X	X	X	X
Humerus proximal	n/a	n/a			X			X
Humerus distal	n/a	n/a				X		
Radius proximal		n/a						
Radius distal	n/a	X	X	X	X	X	X	X
Carpals	n/a	n/a		1		1	2	2
Acetabulum	n/a			X				
Femur proximal	n/a							
Femur distal	n/a	n/a			X	X		X
Patella	n/a	n/a						
Tibia proximal	n/a	n/a						
Tibia distal	n/a	n/a						
Astragalus			X	X			X	X
Calcaneum	n/a							X
Centroquartal	n/a	X	X	X	X	X	X	X

Table 3: 16. Epiphysial fusion in feet of Dexter steers

Epiphyses of the Feet in Approximate Order of Fusion
Ages of fusion after Silver 1969

F = Fused, JF = Just Fused, U = Unfused

	Carrot (28 months)			Parsnip (18 months)			Butterbox Steer (17 months)		
	U	JF	F	U	JF	F	U	JF	F
by 18 months									
Prox Ph 2		8			8				8
Prox Ph 1	4	4		5	3			8	
by 2-3 years									
Dist mc	2			2			2		
Dist mt	2			2			2		

Table 3:17 Distribution of osteochondrosis depressions on feet of Dexter steers

Sire	Pug	Finian	Saprophyte
Name	Carrot	Parsnip	Butterbox steer
Metacarpal proximal	L & R	L & R	
Metacarpal distal		L	R
Metatarsal proximal	L & R	L & R	
Metatarsal distal		L & R	
Phalanx 1 proximal	3	3	
Phalanx 1 distal	8	5	3
Phalanx 2 proximal	2	5	2
Phalanx 2 distal	7	8	
Phalanx 3	8	8	3

Table 3: 18 Karst and Aurelian, distribution of osteochondrosis depressions

X = present n/a = not applicable, bone not extant

	Karst	Aurelian	Aurelian n/a
Scapula glenoid	L & R		L & R
Humerus proximal			L
Humerus distal	L & R		L
Radius proximal			L
Radius distal	L & R	R	L
Carpals	4	3	L
Acetabulum			
Femur proximal			R
Femur distal			R
Patella			L & R
Tibia proximal			
Tibia distal			
Astragalus	L faint	L & R faint	
Calcaneum			
Centroquartal	L faint	L & R	
Metacarpal proximal	R	L & R	
Metacarpal distal			
Metatarsal proximal	L & R		
Metatarsal distal		L faint	
Phalanx 1 proximal			
Phalanx 1 distal	4		
Phalanx 2 proximal			
Phalanx 2 distal	8	4 & 3 faint	
Phalanx 3	3 faint	2 & 2 faint	

Table 3: 19 Karst and Aurelian, epiphysial fusion

Epiphyses in Approximate Order of Fusion
Ages of fusion after Silver 1969

F = Fused, JF = Just Fused, U = Unfused

Karst and Aurelian 17 months. One record for each beast

	Karst			Aurelian (extant bones only)		
	U	JF	F	U	JF	F
by 18 months						
Scap tub			X			
Acet symph			X			X
Prox rad			X			X
Dist hum			X			X
by 2-3 years						
Dist tib	X				X	
by 3.5-4 years						
Prox cal	X			X		
Prox fem	X			X		
Dist rad	X			X		
Prox hum	X			X		
Prox tib	X			X		
Dist fem	X			X		
Prox uln	X					
Feet						
by 18 months						
Prox Ph 2			X			X
Prox Ph 1		X			X	
by 2-3 years						
Dist mc	X				X	
Dist mt	X				X	

Table 3: 20 Mandible Wear Stages, Young Dexters

Tooth Wear Stages (after Grant 1982)

			TWS			MWS
	dp4	P4	M1	M2	M3	
Carrot	j		g	d		
			12	9		21
Parsnip	j		f	a		
			11	6		17
Bboxbull	j		g	a		
			12	6		18
Bboxsteer	j		f	a		
			11	6		17
Aurelian	j		g	b		
			12	7		19
Karst	j		g	b		
			12	7		19
Dusty		b	j	g	c	
		7	14	12	8	34

Table 3: 21 Dusty epiphysial fusion

	Epiphyses in Approximate Order of Fusion	U	JF	F
	by 18 months			
	Scap tub			X
	Acet symph			X
	Prox rad			X
	Dist hum			X
	Prox Ph 2			X
	Prox Ph 1			X
	by 2-3 years			
	Dist tib			X
	Dist mc			X
	Dist mt			X
	by 3.5-4 years			
	Prox cal		X	
	Prox fem		X	
	Dist rad		X	
	Prox hum		X	
	Prox tib	X		
	Dist fem		X	
	Prox uln			X
	by >5 years			
Cervical	Ant vert ep	3	2	
	Post vert ep	6		
Thoracic	Ant vert ep	9	4	
	Post vert ep	7	6	
Lumbar	Ant vert ep	2	4	
	Post vert ep		6	

Table 3: 22 Romano-British calf bones from Nantwich and Dexter calf

Length of diaphysis in mm	Humerus	Radius	Metacarpal	Femur	Tibia	Metatarsal
Nantwich	97	101	98	120	129	115
Dexter	97	101	96	119	131	114

Table 3: 23 Emden: foetal calves

Days gestation	230-240	240-250	250-260	260-270	270-280
Scapula		1	5	6	
Humerus	1	4	6	3	1
Radius		2	1	7	1
Metacarpus		1	1		3
Femur	1			3	1
Tibia				2	2
Metatarsal		1	2	2	2

Table 3: 24 Monkseaton Chapel Lane foetal calf bone lengths

Radius, right	82.4 mm
Metacarpal, right	84.2 mm
Tibia, left	106.4 mm
Metatarsal, left	96.9 mm

Table 3: 25 Occurrence of veal in Thacker's cookery book

	Recipes	Bills of Fare
January	3	X
February	4	X
March	5	X
April	5	X
May	4	X
June		X
July	1	X
August	2	
September	1	X
October	3	X
November	1	X
December	1	

Table 3: 26 Thacker's Bills of Fare for the Residency of the Dean

29th Sept	Veal collops	6th Oct	Daub'd veal Calf's head	13th Oct	Veal collops
30th Sept		7th Oct	Breast of veal	14th Oct	Veal collops
1st Oct	Loin of veal	8th Oct	Loin of veal	15th Oct	Loin of veal
2nd Oct	Veal collops	9th Oct	Loin of veal	16th Oct	
3rd Oct	Breast of veal	10th Oct	Calf's head	17th Oct	Veal collops
4th Oct	Calf's head hash	11th Oct	Ragoo'd veal	18th Oct	Calf's head hash
5th Oct	Veal collops	12th Oct	Veal collops	19th Oct	Veal cutlets

Table 3:27 Durham, Dexter and Jersey calf bone lengths

Metacarpal	Medial Length, mm	Metatarsal	Lateral length, mm
11, The College	122.4	11, The College	143.6
Tinkerbell	129.1	11, The College	142.2
Dozey	103.2	Tinkerbell	148.0
Jersey	138.5	Dozey	122.5
Gundrada	111.9	Jersey	167
Luke	103.3	Gundrada	131.8
		Luke	125.3

Table 3: 28 Durham and Dexter TWS (after Grant 1982)

	Dlp4	M1
11, The College	TWS 8	TWS 1
Prebend's Bridge	TWS 7	TWS 1
Prebend's Bridge	TWS 8	TWS 1
Prebend's Bridge	TWS 8	N/A
Gundrada	TWS 7	TWS 1
Tinkerbell	TWS 9	TWS 2
Luke	TWS 9	TWS 2
Dozey	TWS 11	TWS 3

Table 4:1. Vycanny Conqueror's Glenisla: surviving milk records

Lactation number	Date calved	Days in milk	Lbs/Kgs of milk	Butterfat
1st	5/4/61	305	4759/2163	4.12%
2nd	24/4/62	294	4082/1855	3.71%
4th	23/4/64	267	4046/1839	3.83%
7th	No record	305	4703/2137	3.86%
9th	No record	266	4513/2051	3.47%
10th	8/4/70	290	4720/2145	3.64%
11th	9/4/71	304	4953/2251	3.83%
12th	14/4/72	305	4188/1903	3.87%
14th	11/5/76	299	1775/806	3.93%
15th	25/4/77	305	1654/751	3.67%

Table 4: 2 Mandible Wear Stages for the Vycanny cows

Glenteitney	P4	M1	M2	M3	MWS
Left	H	M	K	J	
Right		M	K	K	
Left		17	15	14	46
Right		17	15	15	47
Glenfinlet	P4	M1	M2	M3	MWS
Left	H	M	K	J	
Right	H	M	K	J	
Left		17	15	14	46
Right		17	15	14	46
Kirstie	P4	M1	M2	M3	MWS
Left	G	M	K	K	
Right	G	M	K	K	
Left		17	15	15	47
Right		17	15	15	47
Keepsake	P4	M1	M2	M3	MWS
Left	G	K	K	J	
Right	G	K	K	H	
Left		15	15	14	44
Right		15	15	13	43

Table 4: 3a. Vycanny cows: Greatest Length Measurements (mm)

	Glenteitney	Glenteitney	Glenfinlet	Glenfinlet	Kirstie	Kirstie	Keepsake	Keepsake
	L	R	L	R	L	R	L	R
Humerus	231	231	235	235	247	245	234	234
Metacarpal			153	153	156	155	153	153
Femur	296	298	288	288	299	298	287	287
Tibia	272	271	269	266	276	275	262	262

Table 4: 3b. Vycanny cows: Estimated Withers Heights (in m) from above measurements, using factors of Matolcsi (Driesch & Boessneck 1974, 336)

	Glenteitney	Glenteitney	Glenfinlet	Glenfinlet	Kirstie	Kirstie	Keepsake	Keepsake
	L	R	L	R	L	R	L	R
Humerus	0.95	0.95	0.97	0.97	1.08	1.01	0.96	0.96
Femur	0.95	0.96	0.93	0.93	0.96	0.96	0.92	0.92
Tibia	0.93	0.93	0.92	0.91	0.95	0.94	0.90	0.90

Table 4: 3c. Estimated Withers Heights of Vycanny cows from metacarpal measurements, using average of factors for cows and steers given by Boessneck (B), Zalkin (Z), Fock (F) and Matolcsi (M) (Driesch & Boessneck 1974, 336)

	Glenfinlet	Glenfinlet	Kirstie	Kirstie	Keepsake	Keepsake
	L	R	L	R	L	R
Metacarpal (B)	0.93	0.93	0.98	0.97	0.93	0.93
Metacarpal (Z)	0.91	0.91	0.93	0.92	0.91	0.91
Metacarpal (F)	0.91	0.91	0.93	0.93	0.91	0.91
Metacarpal (M)	0.92	0.92	0.94	0.93	0.92	0.92

Table 4: 3d. Estimated Withers Heights of Vycanny cows from metacarpal measurements, using factors for cows (Driesch & Boessneck 1974, 336)

	Glenfinlet	Glenfinlet	Kirstie	Kirstie	Keepsake	Keepsake
	L	R	L	R	L	R
Metacarpal (B)	0.99	0.99	1.00	1.00	0.99	0.99
Metacarpal (Z)	0.93	0.93	0.95	0.94	0.93	0.93
Metacarpal (F)	0.95	0.95	0.96	0.97	0.95	0.95
Metacarpal (M)	0.94	0.94	0.96	0.95	0.94	0.94

Table 4: 4. Green Shiel TWS/MWS

Green Shiel	Molar 1 TWS	Molar 2 TWS	Molar 3 TWS	MWS
#1	K/15	J/14	E/10	39
#2	K/15	H/13	E/10	38
#3	L/16	K/15	J/14	45
#4	L/16	K/15	J/14	45

Table 4: 5a. Green Shiel: Greatest Lengths (GL in mm) and estimated Withers Heights (WH in m), using factors of Matolcsi (Driesch & Boessneck 1974, 336)

Green Shiel	Humerus	Femur	Tibia
#1	GL 255	GL 321	GL 291
#2	GL 254	GL 324	GL 294
#3	GL 234		GL 293
#4	GL 234		
#1	WH 1.05	WH 1.0	WH 1.0
#2	WH 1.03	WH 1.04	WH 1.01
#3	WH 0.96		WH 1.01
#4	WH 0.96		

Table 4: 5b. Green Shiel: Estimated Withers Heights from metapodial measurements, using average of factors for cows and steers given by Zalkin (Driesch & Boessneck 1974, 336)

Green Shiel	Metacarpal		Metatarsal	
#1	GL 174	WH 1.06	GL 200	WH 1.09
#2	GL 175	WH 1.07	GL 189	WH 1.03
#3	GL165	WH 1.00	GL 191	WH 1.04
#4	GL 166	WH 1.01	GL 197	WH 1.07

Table 5: 1 MWS for the Dexter Suckler Cows (a.m. = ante mortem)

Abby	P4	M1	M2	M3	MWS
Left	F	L	K	J	
Right	Abnormal wear	Abnormal wear	a.m. loss	a.m. loss	
Left		16	15	14	45
Right					

Betula	P4	M1	M2	M3	MWS
Left					
Right	G	L	K	G	
Left					
Right		16	15	12	43

Glenalmond	P4	M1	M2	M3	MWS
Left	G	M	L	K	
Right	G	M	L	K	
Left		17	16	15	48
Right		17	16	15	48

Chalena	P4	M1	M2	M3	MWS
Left	H	L	K	H	
Right	H	L	K	H	
Left		16	15	13	44
Right		16	15	13	44

Meadow Pipit	P4	M1	M2	M3	MWS
Left	F	L	K	J	
Right	F	L	K	J	
Left		16	15	14	45
Right		16	15	14	45

Clover	P4	M1	M2	M3	MWS
Left	G	M	Broken (a.m.)	G (no pillar)	
Right	F	M	L	G (no pillar)	
Left		17		12	n/a
Right		17	16	12	45

Cassie	P4	M1	M2	M3	MWS
Left	To find	N	L	L	
Right	J	M	L	L	
Left		18	16	16	50
Right		17	16	16	49

Chevette	P4	M1	M2	M3	MWS
Left	H	M	L (no pillar)	G (no pillar)	
Right	To find	M	L (no pillar)	G (no pillar)	
Left		17	16	12	45
Right		17	16	12	45

Table 5:2a. Suckler cows: Greatest Length Measurements (mm)

	Abby	Glenalmond	Chalena	Meadow Pipit	Clover	Cassie	Chevette	Dusty
	L	L	L	L	L	L	L	L
Humerus	260	254	286	271	257	261	262	
Metacarpal	176	178	182	174	168	168	176	174
Femur	323	321	349	328	320	336	319	
Tibia	299	305	318	304	294	303	289	

Table 5: 2b. Suckler cows: Estimated Withers Heights (in m) from above measurements, using factors of Matolcsi (Driesch & Boessneck 1974, 336)

	Abby	Glenalmond	Chalena	Meadow Pipit	Clover	Cassie	Chevette
	L	L	L	L	L	L	L
Humerus	1.07	1.05	1.18	1.12	1.06	1.08	1.08
Femur	1.04	1.03	1.12	1.05	1.03	1.08	1.03
Tibia	1.03	1.05	1.09	1.04	1.01	1.04	0.99

Table 5: 2c. Suckler cows: Estimated Withers Heights from metacarpal measurements, using average of factors for cows and steers given by Boessneck (B), Zalkin (Z), Fock (F) and Matolcsi (M) (Driesch & Boessneck 1974, 336)

	Abby	Glenalmond	Chalena	Meadow Pipit	Clover	Cassie	Chevette	Dusty
	L	L	L	L	L	L	L	L
Metacarpal (B)	1.14	1.15	1.18	1.13	1.09	1.09	1.14	1.13
Metacarpal (Z)	1.07	1.08	1.11	1.06	1.02	1.02	1.07	1.06
Metacarpal (F)	1.07	1.08	1.11	1.06	1.02	1.02	1.07	1.06
Metacarpal (M)	1.08	1.10	1.12	1.07	1.03	1.03	1.08	1.07

Table 5: 2d. Suckler cows: Estimated Withers Heights from metacarpal measurements, using factors for cows (Driesch & Boessneck 1974, 336)

	Abby	Glenalmond	Chalena	Meadow Pipit	Clover	Cassie	Chevette	Dusty
	L	L	L	L	L	L	L	L
Metacarpal (B)	1.11	1.12	1.14	1.09	1.06	1.06	1.11	1.09
Metacarpal (Z)	1.05	1.06	1.08	1.04	1.00	1.00	1.05	1.04
Metacarpal (F)	1.05	1.06	1.09	1.04	1.00	1.00	1.05	1.04
Metacarpal (M)	1.06	1.07	1.10	1.05	1.01	1.01	1.06	1.05

Table 6: 1 Stages of epiphysial fusion, Hadza and Dusty

Epiphyses in Approximate Order of Fusion

	Dusty=X Hadza=Y	Unfused	JustFusing	Fused
	by 18 months			
	Scap tub			XY
	Acet symph			XY
	Prox rad			XY
	Dist hum			XY
	Prox Ph 2			XY
	Prox Ph 1			XY
	by 2-3 years			
	Dist tib			XY
	Dist mc		Y	X
	Dist mt		Y	X
	by 3.5-4 years			
	Prox cal	Y	X	
	Prox fem	Y	X	
	Dist rad	Y	X	
	Prox hum	Y	X	
	Prox tib	XY		
	Dist fem	Y	X	
	Prox uln	Y		X
	by >5 years			
Cervical	Ant vert ep	3	2	
	Post vert ep	6		
Thoracic	Ant vert ep	9	4	
	Post vert ep	7	6	
Lumbar	Ant vert ep	2	4	
	Post vert ep		6	

Table 6: 2 Tooth Wear Stages for Hadza and Dusty

	P4	M1	M2	M3	MWS
Hadza	b/7	h/13	g/12	g/12	37
Dusty	b/7	j/14	g/12	c/8	34

Table 6: 3 Shapwick, metapodial measurements and estimated withers heights

	Side	Greatest Length (mm)	Distal Breadth (mm)	Withers Height estimate (m)
Metacarpal	Left	172	49.6	0.94
Metacarpal	Right	175	52.8	1.07
Metacarpal	Left	179	57.3	1.09
Metacarpal	Right	180	57.0	1.10
Metacarpal	Right	185	57.9	1.13
Metacarpal	Left	187	56.7	1.14
Metacarpal	Left	187	59.3	1.14
Metacarpal	Right	broken	57.9	
Metatarsal	Left	194	47.5	1.06
Metatarsal	Left	199	50.1	1.08
Metatarsal	Right	204	53.4	1.11
Metatarsal	Left	212	damaged	1.15
Metatarsal	Right	216	54.7	1.18
Metatarsal	Right	broken	54.4	

Table 6: 4 Shapwick epiphysial fusion

Epiphyses in approximate order of fusion (after Silver 1969).

	Fused	Just Fused	Unfused
By 18 months			
Scapula tuberosity	9		
Acetabulum symphysis	7		1
Proximal radius	7		
Distal humerus	8		
Proximal phalanx 2	30		
Proximal phalanx 1	26	3	
By 2-3 years			
Distal tibia	9	2	1
Distal metacarpal	9		1
Distal metatarsal	7		3
By 3.5-4 years			
Proximal calcaneum	3	2	4
Proximal femur	1	2	7
Distal radius	1		8
Proximal humerus	1		4
Proximal tibia	2		9
Distal femur	1	1	8
Prox and distal ulna			6
By >5 years			
Anterior vertebral epiphyses	22	21	113
Posterior vertebral epiphyses	20	10	126

Table 6: 5. St Giles by Brompton Bridge, cattle tooth wear stages compared with Hadza and Dusty

	P4	M1	M2	M3	MWS
Hadza	b/7	h/13	g/12	g/12	37
Dusty	b/7	j/14	g/12	c/8	34
BSG1	c/8	k/15	h/13	e/10	38
BSG4	f/11	k/15	h/13	g/h 12/13	40/41

Table 6: 6 St Giles by Brompton Bridge, comparison of epiphysial fusion with the Dexters Hadza and Dusty

	Epiphyses in Approximate Order of Fusion		
Dusty=X Hadza=Y	BSG1=Z	BSG4=W	
	U	JF	F
by 18 months			
Scap tub			XYW
Acet symph			XYZW
Prox rad			XYZW
Dist hum			XYZW
Prox Ph 2			XY
Prox Ph 1			XYZW
by 2-3 years			
Dist tib			XYZW
Dist mc		Y	XZW
Dist mt		Y	XZW
by 3.5-4 years			
Prox cal	Y	X	ZW
Prox fem	Y	XZW	
Dist rad	Y	X	W
Prox hum	Y	XZW	
Prox tib	XY	ZW	
Dist fem	Y	XZW	
Prox uln	Y	Z	XW

Figure 2: 1. Pedigree of Shorthorn bull Comet

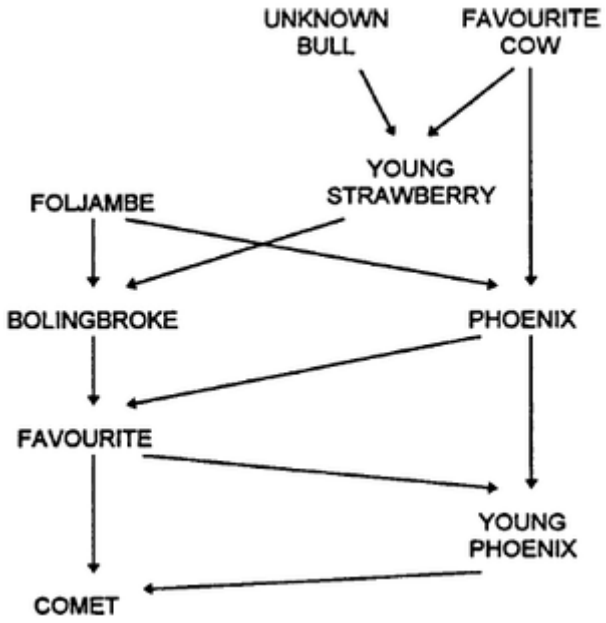


Figure 2: 2a
Dexters and Chillingham, comparison of humerus distal trochlea

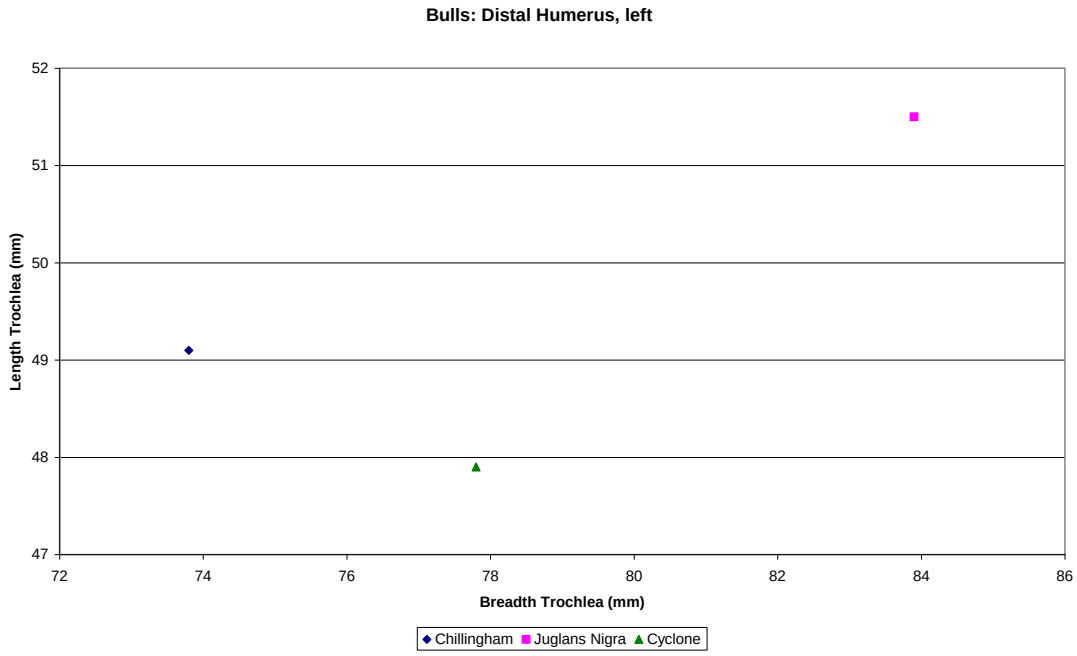


Figure 2: 2b Dexters and Chillingham, comparison of distal tibia

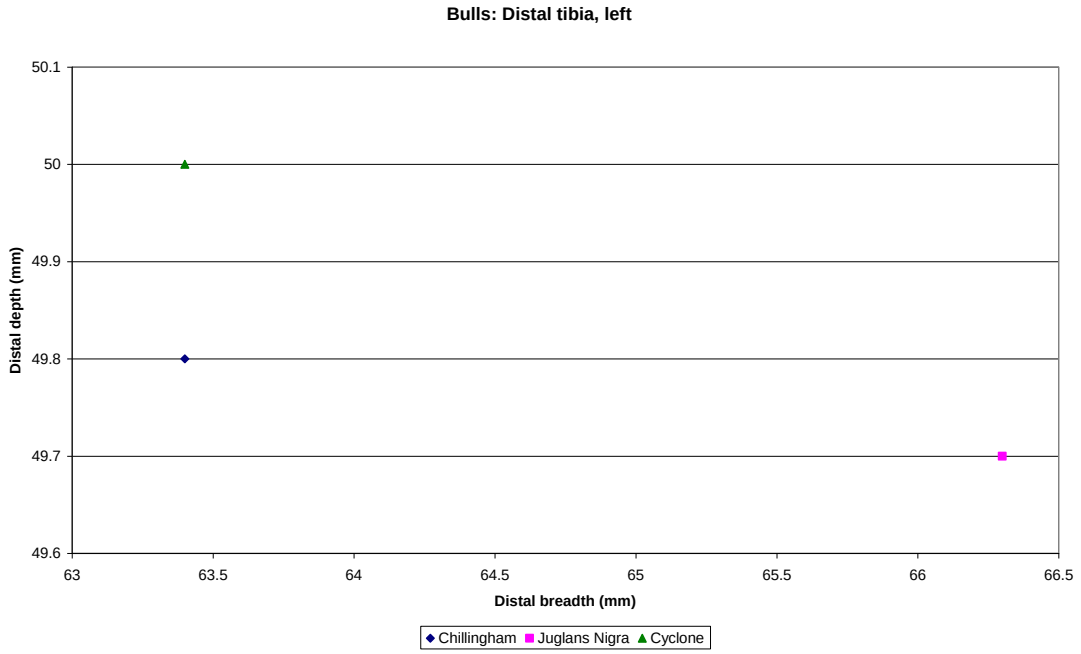


Figure 2: 2c Comparison of humerus distal trochlea between aurochs and Comet with Chillingham and Dexters

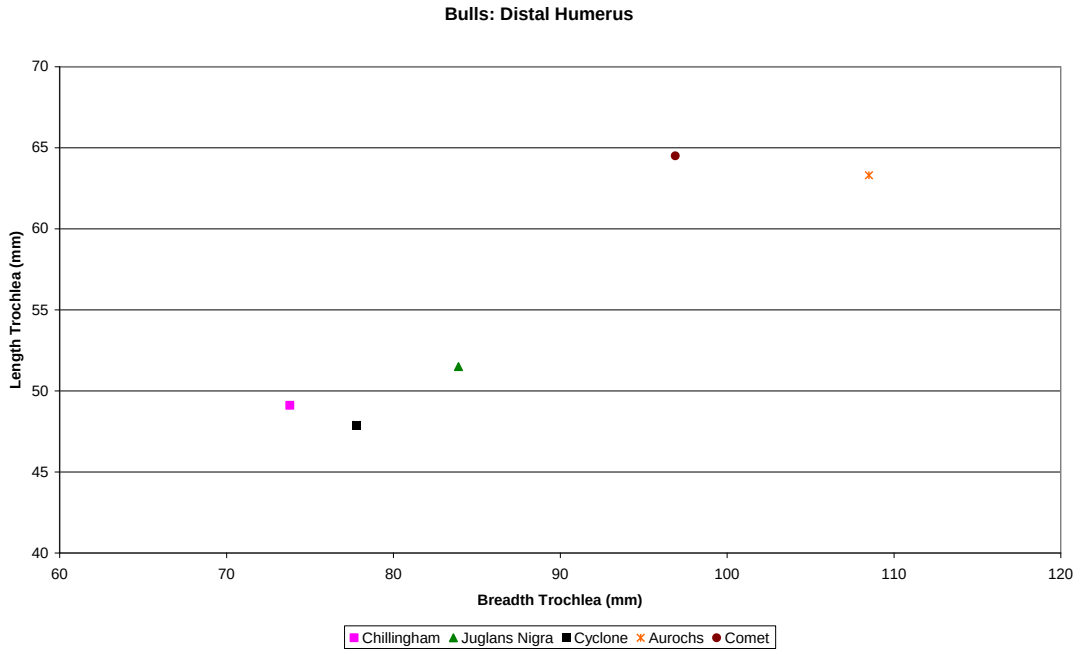


Figure 3: 1 Seasonality of calving in Heck cattle at Oostvordersplassen 2003 (Cis van Vuure pers. comm.) and Chillingham cattle in 1862-1898 and 1953-1984 (after Hall and Hall 1988, 483)

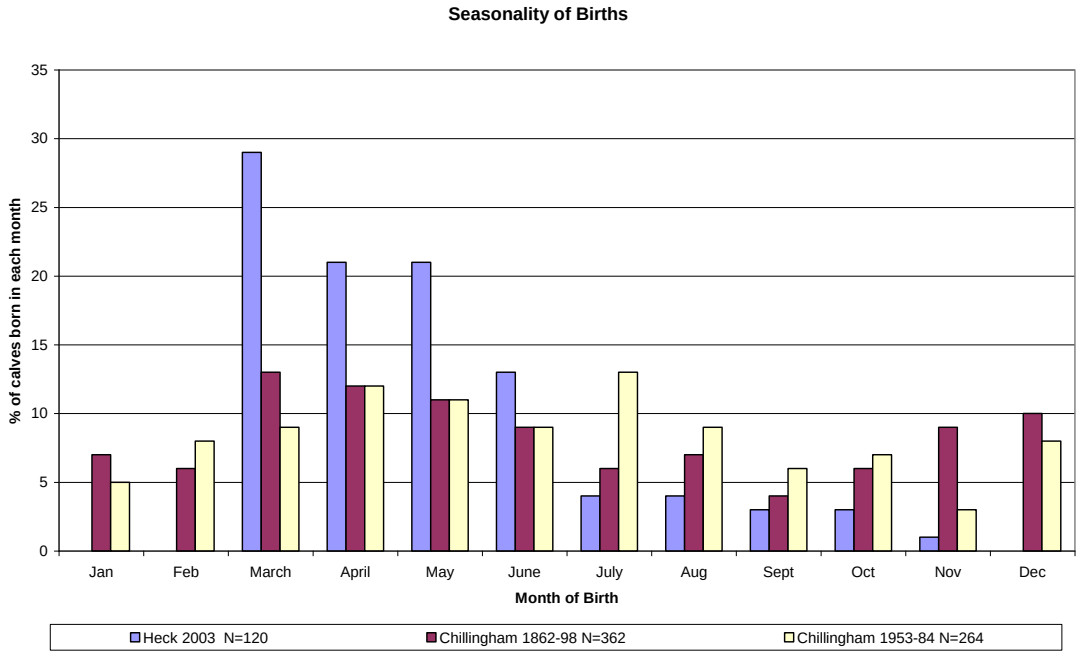


Figure 3: 2 Central Ethiopian Highlands: birth months of calves (after Mukasa-Mugerwa 1989)

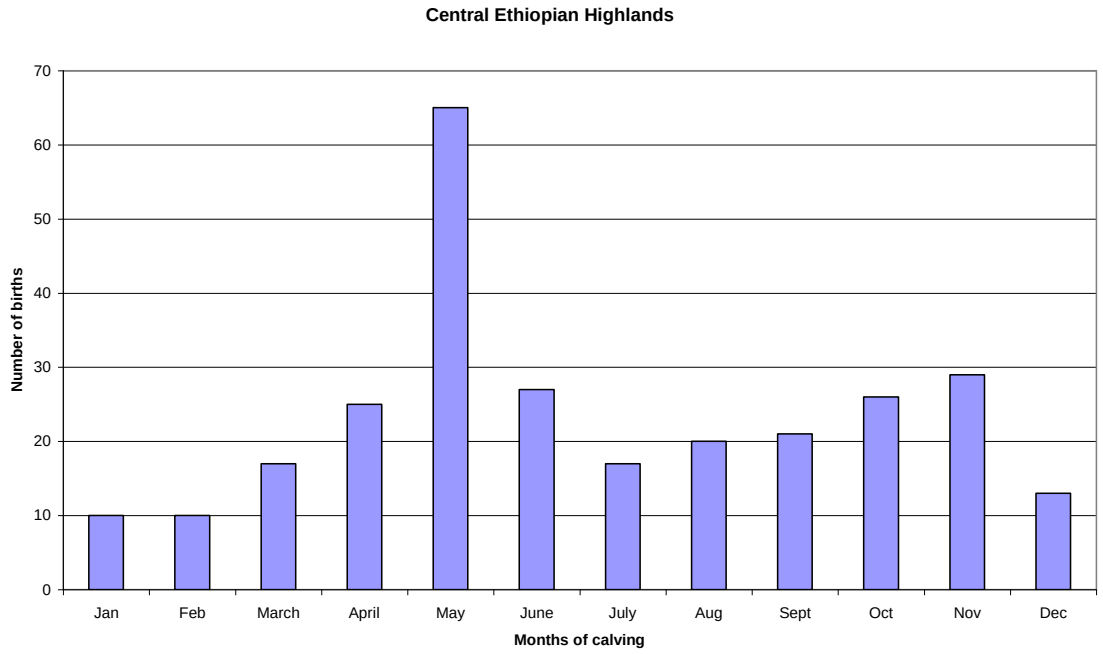


Figure 3: 3. Zanfara Dexter Herd: birth months of calves

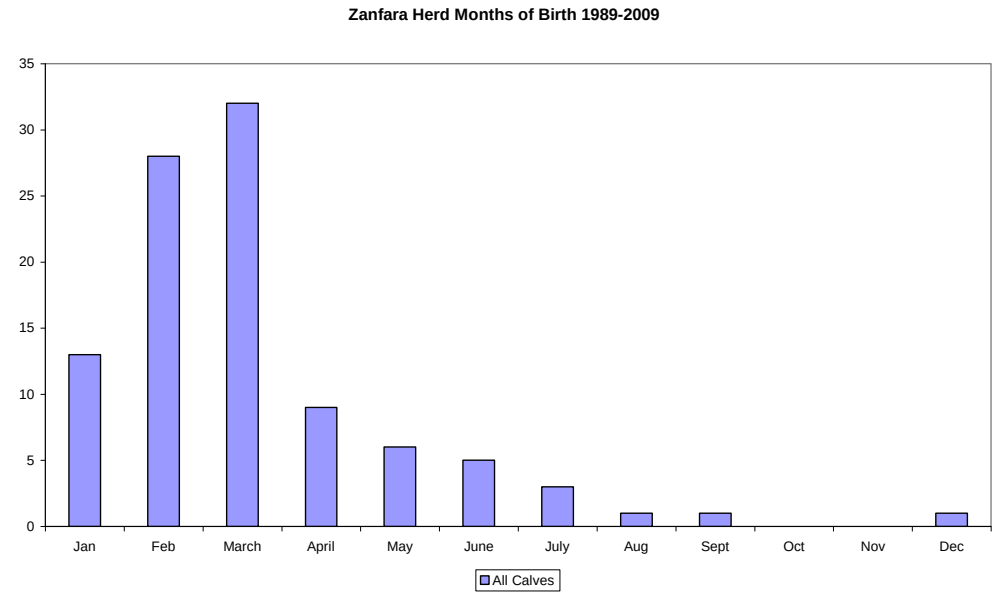


Figure 3: 4. Knotting Dexter Herd: birth months of calves

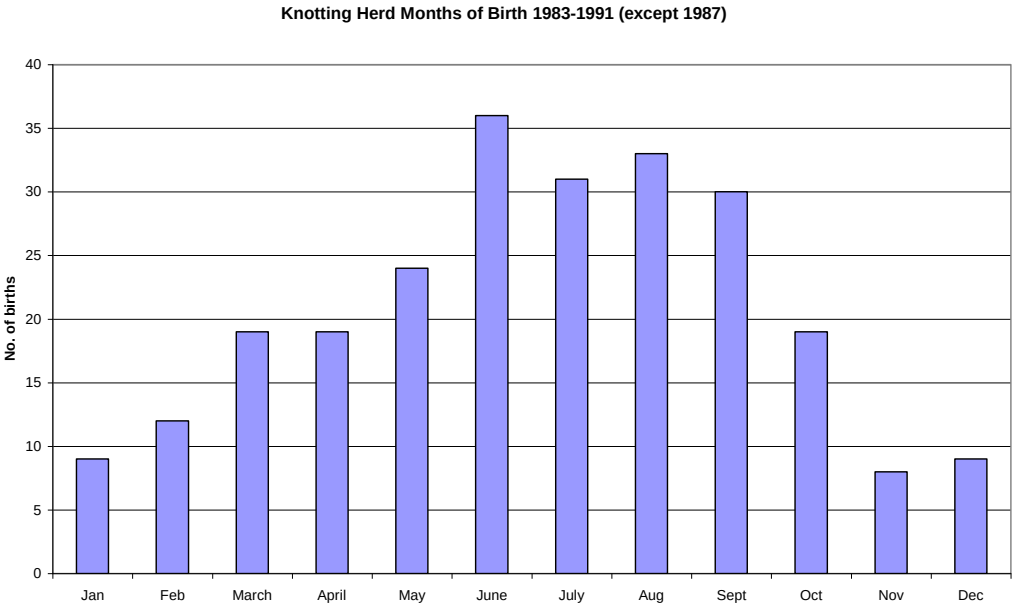


Figure 3: 5a. All Bull and Heifer calves, excluding Knotting Herd

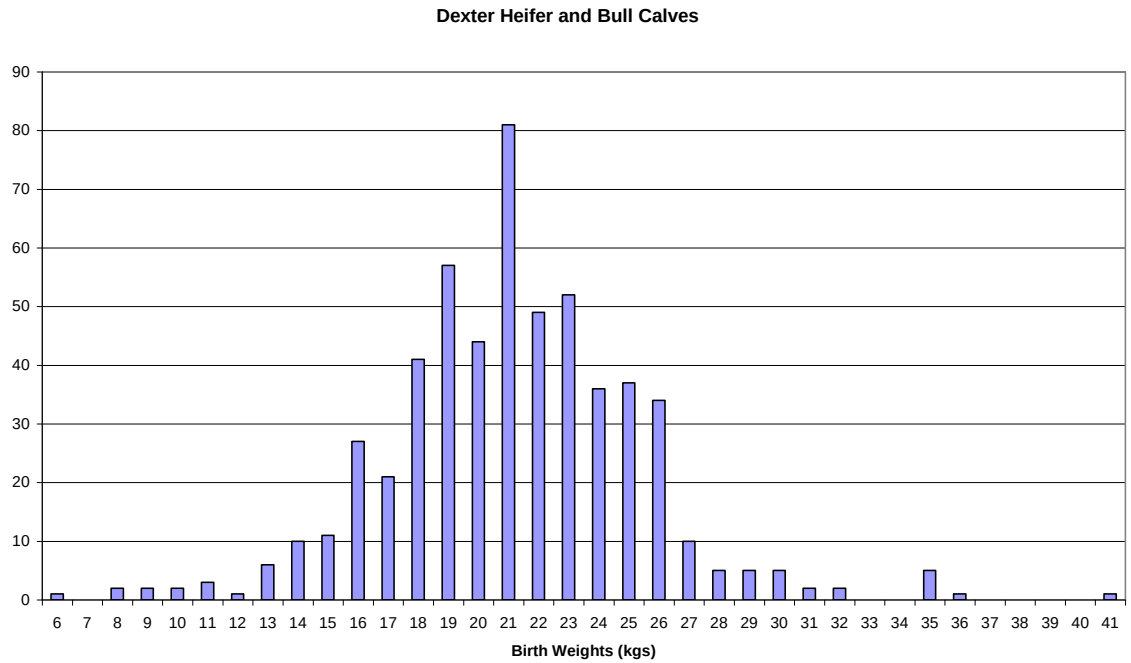


Figure 3: 5b. Bull and Heifer calves, excluding Knotting Herd

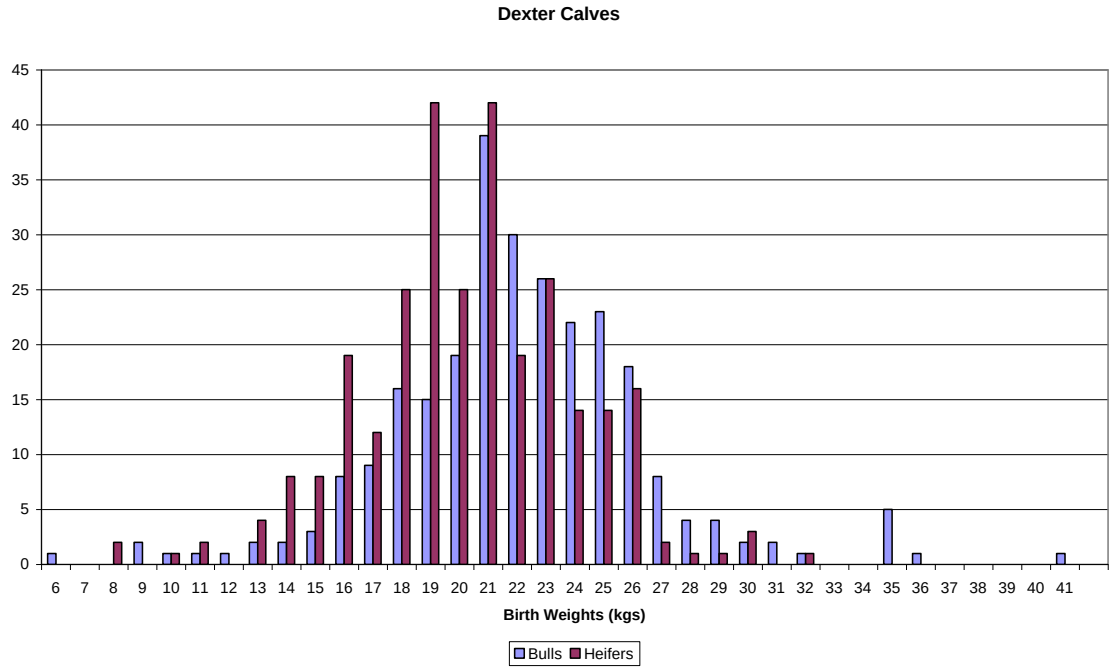


Figure 3: 5c. Bull calves, excluding Knotting Herd

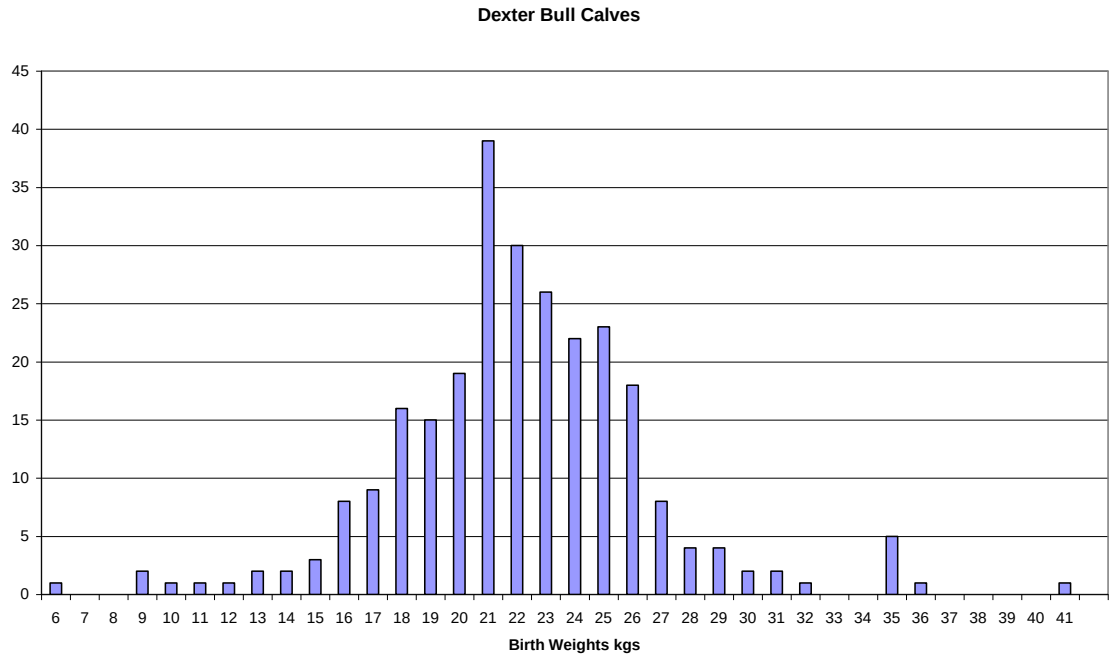


Figure 3: 5d. Heifer calves, excluding Knotting Herd

Figure 3: 5e. Heifer calves, weights in pounds, excluding Knotting Herd

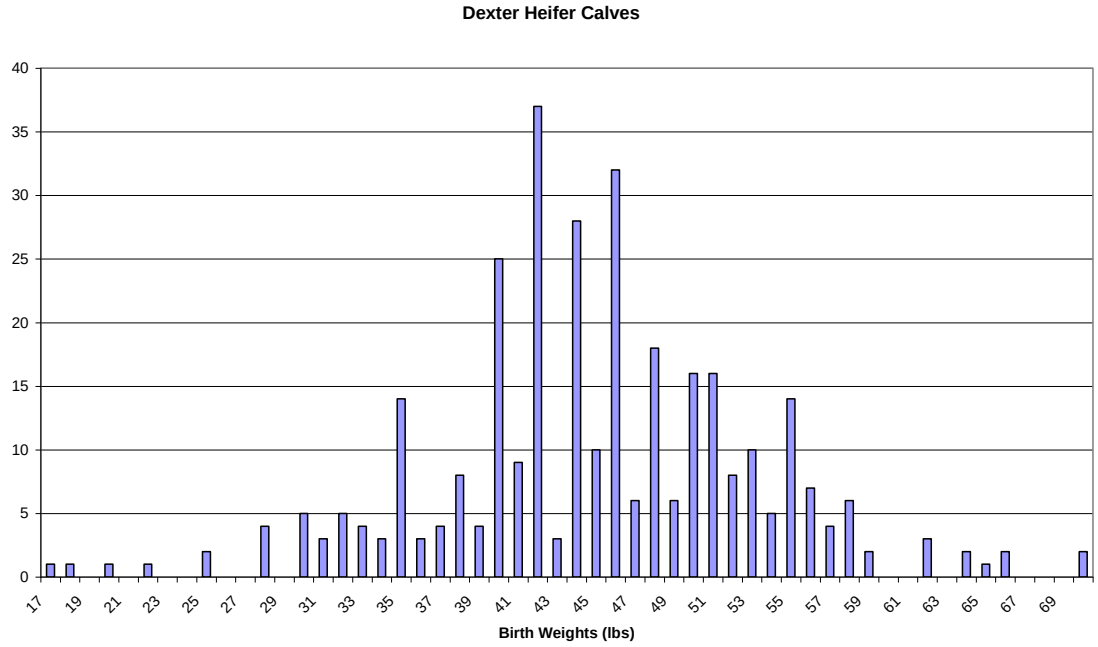


Figure 3: 5f. Knotting herd birth weights

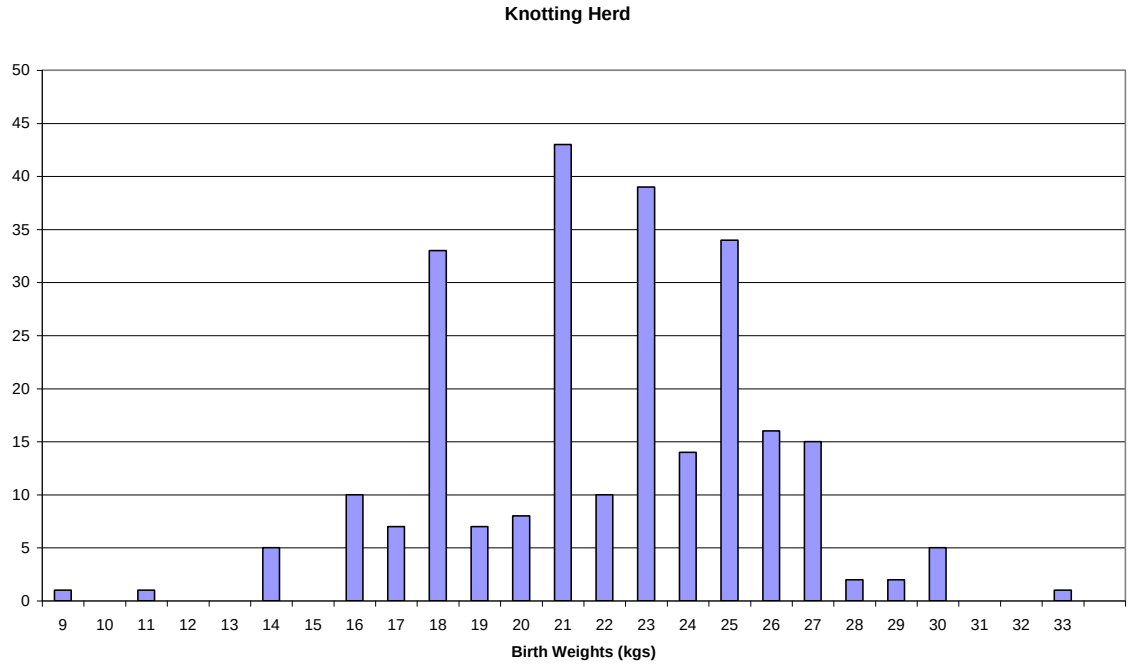


Figure 3: 5g. Knotting herd birth weights compared to all other herds

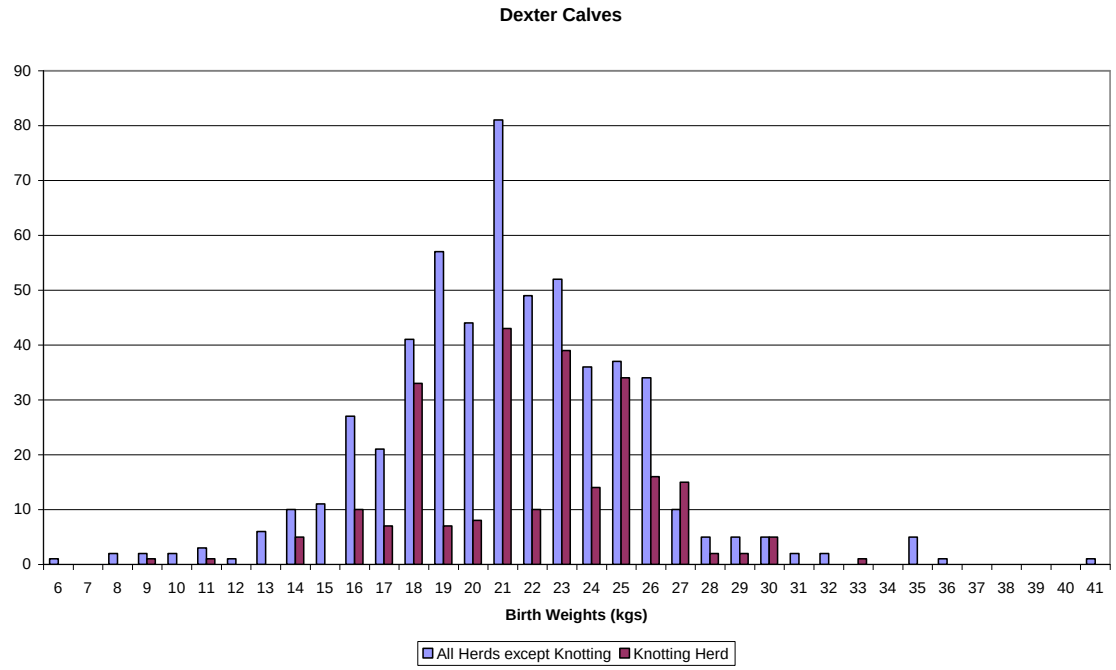


Figure 3: 5h. All Dexter Birth weights, including Knotting

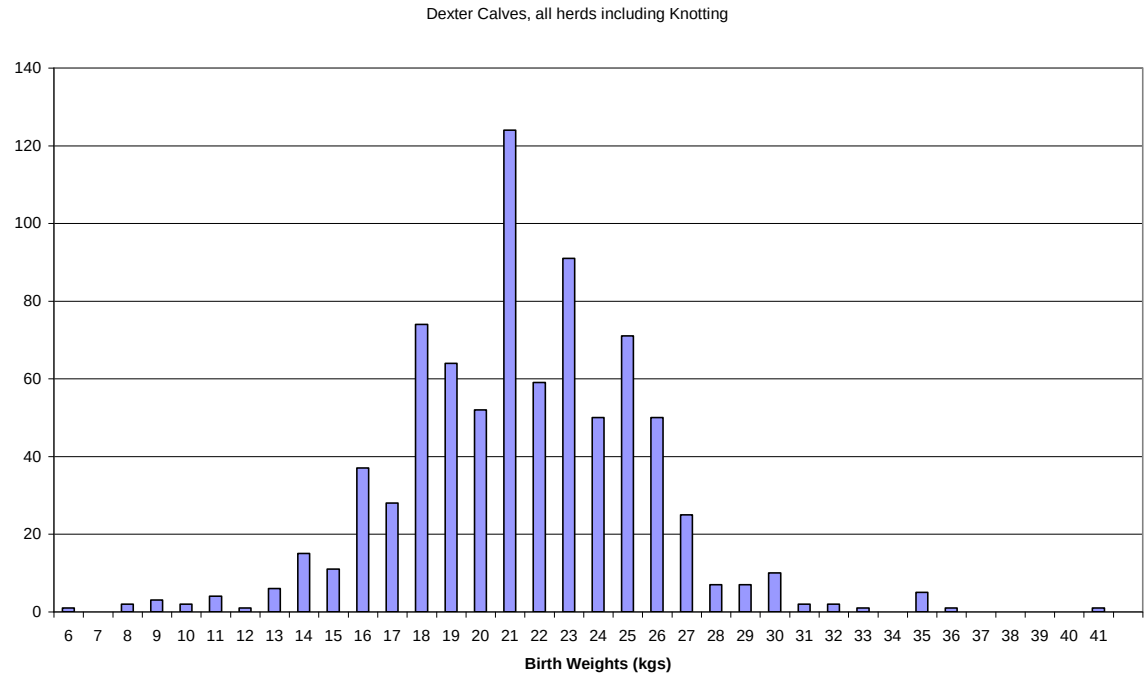


Figure 3: 5i. Knotting Heifer Calves Birth Weights

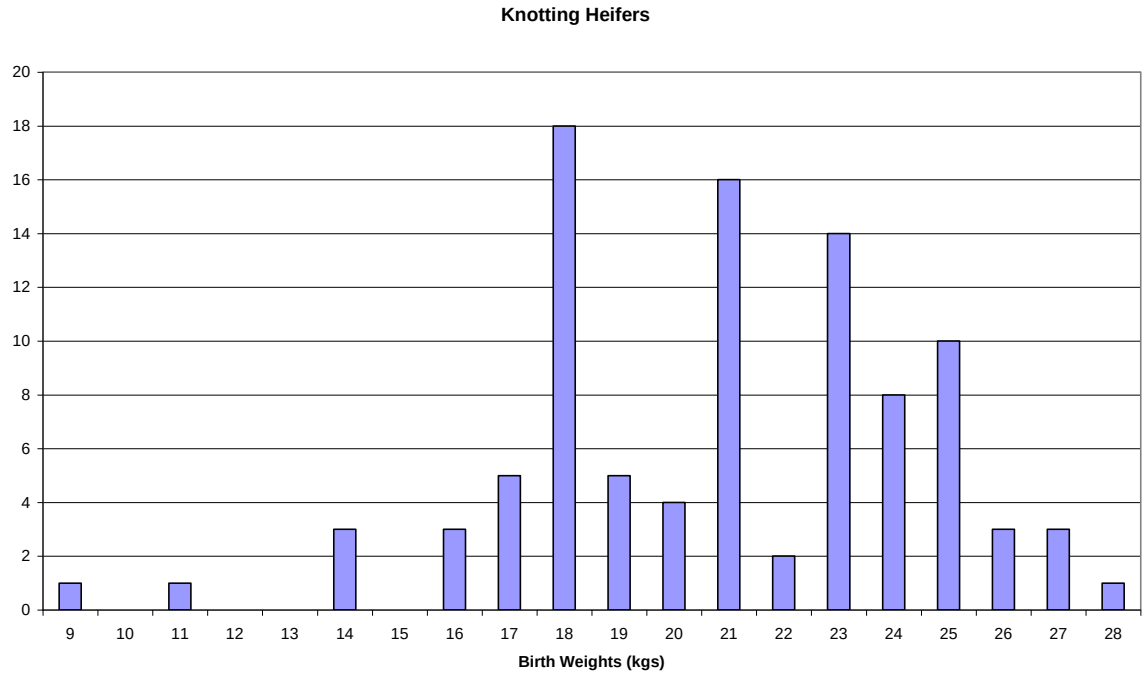


Figure 3: 5j. Knotting Bull Calves Birth Weights

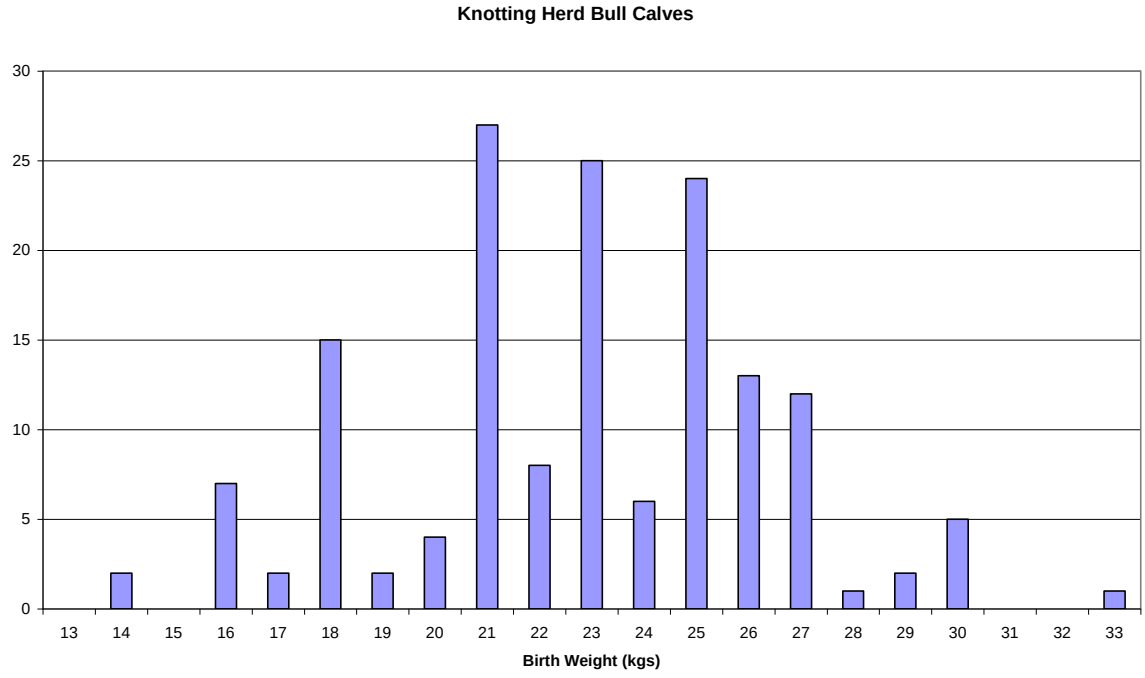


Figure 3: 5k. Knotting Herd Full Term Live Births: Bull and Heifer Calves

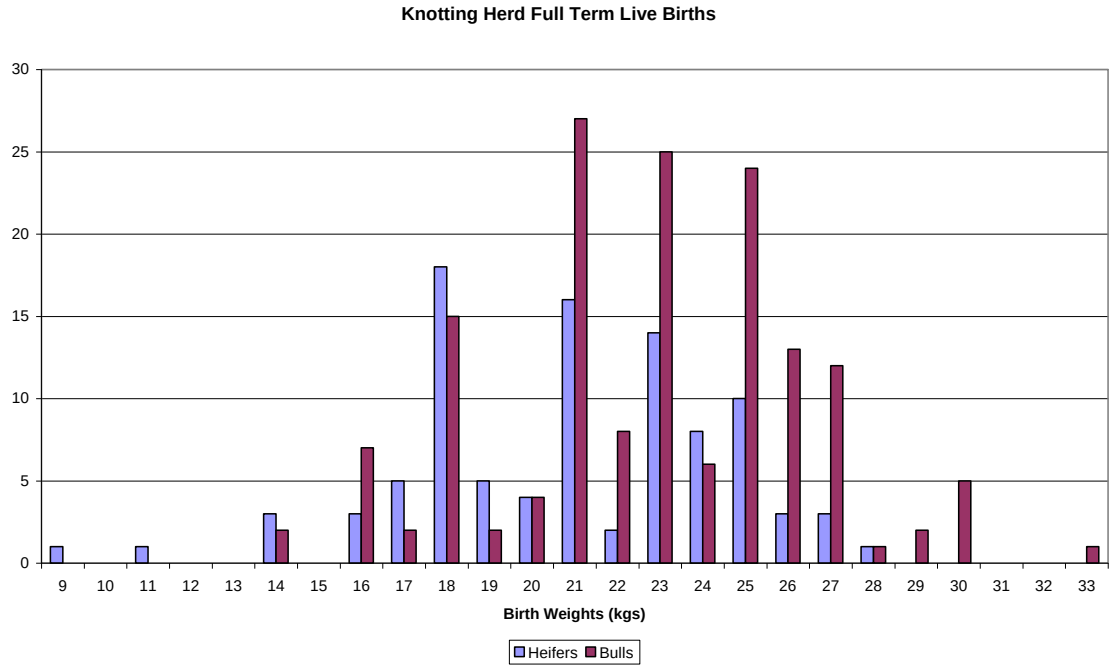


Figure 3: 5l. Knotting Herd Comparison of Live and Stillborn Calf Birth Weights

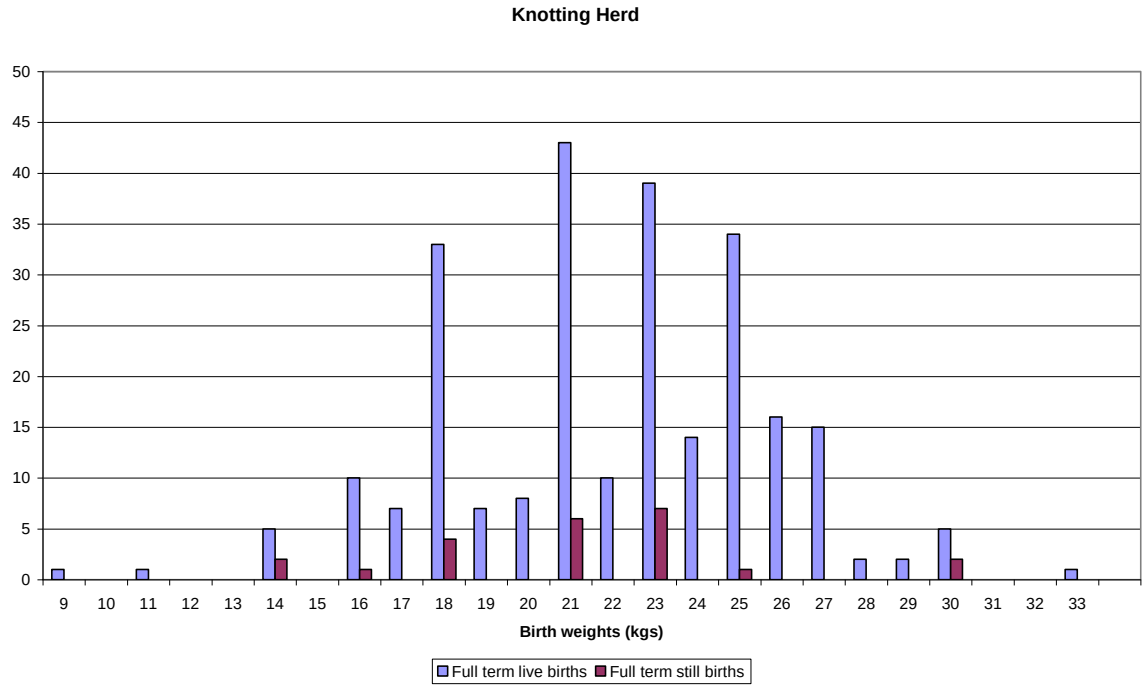


Figure 3: 5m. Knotting Herd Comparison of Full term and Premature Live and Stillborn Calf Birth Weights

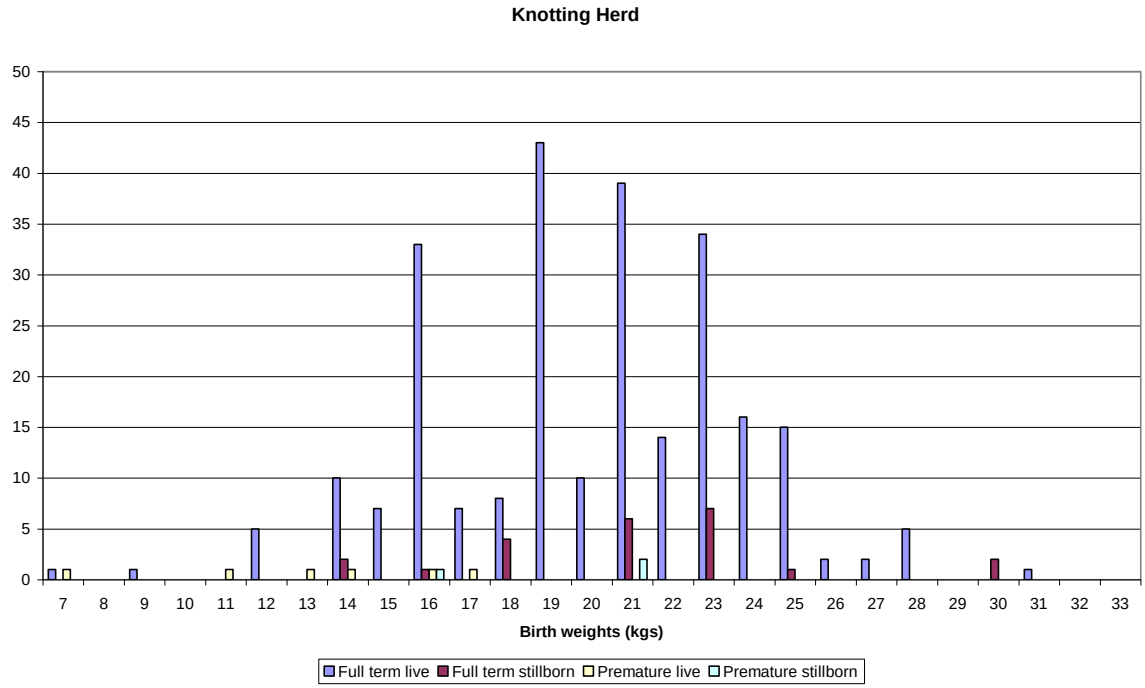


Figure 3: 5n. Harron Herd All Birth Weights

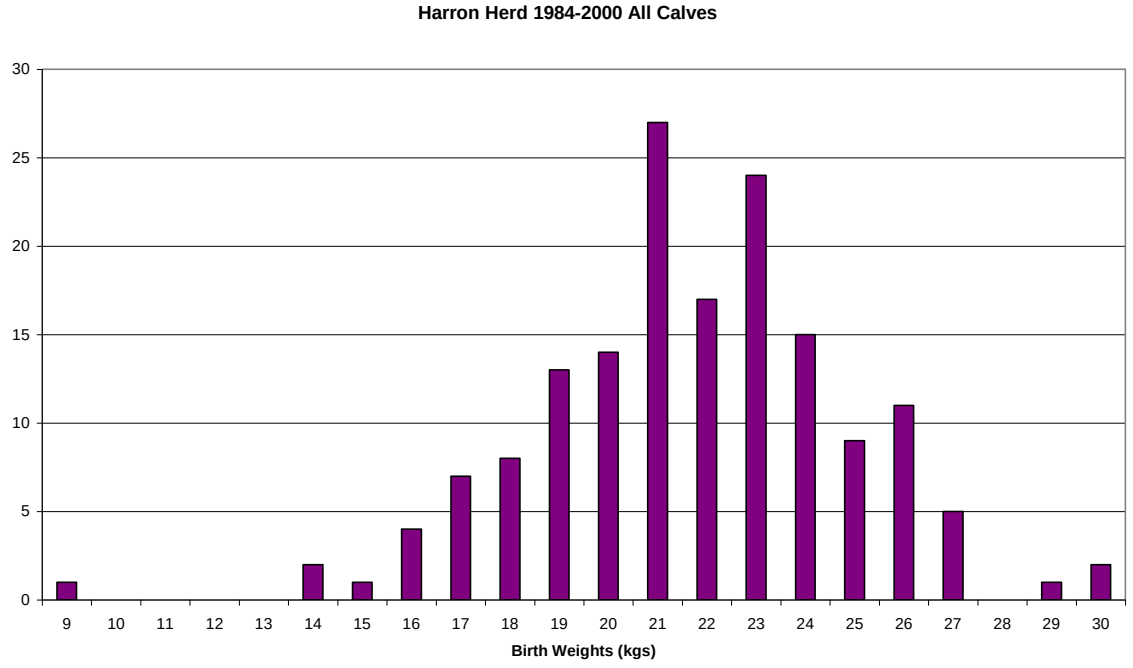


Figure 3: 5o. Harron Herd Birth Weights for Bull and Heifer Calves

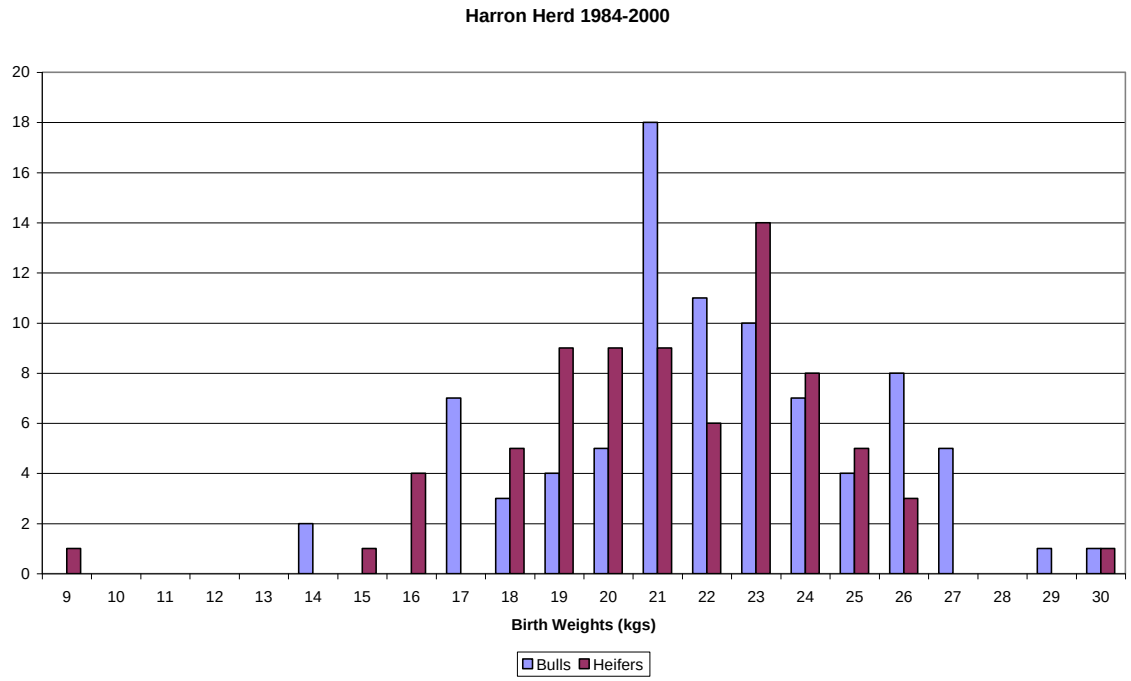


Figure 3: 6 Age distribution of male Dexter beef cull cohort

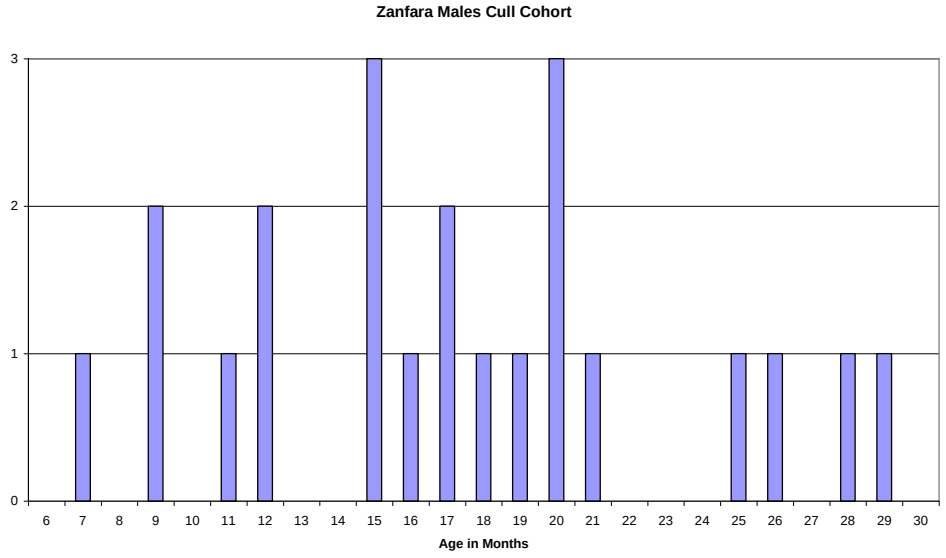


Figure 3:7 Age distribution of beefed male Dexters with some extant bones

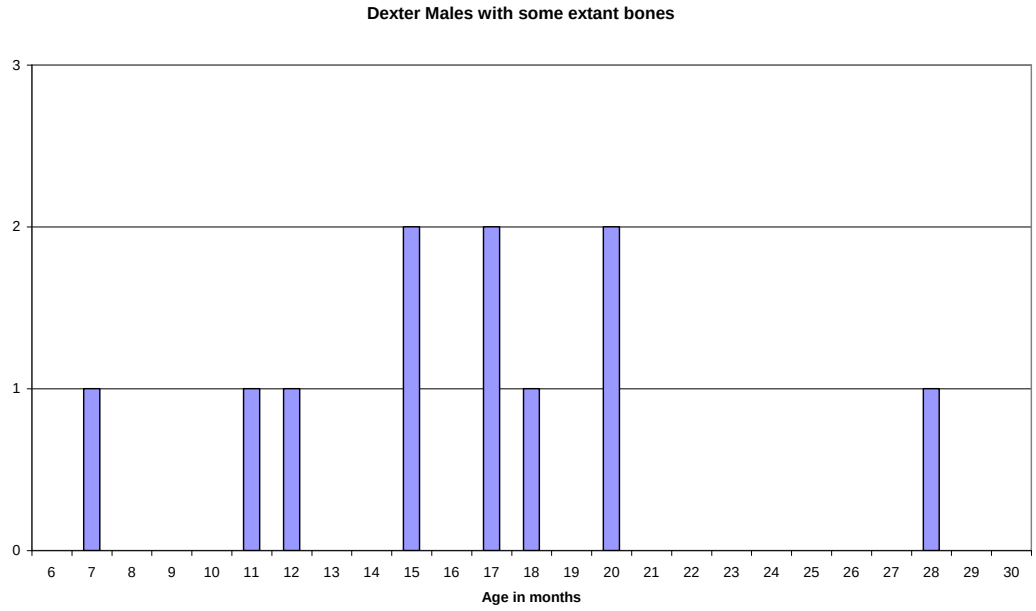


Figure 3:8 Male beef Dexters and Jersey crosses with some extant bones

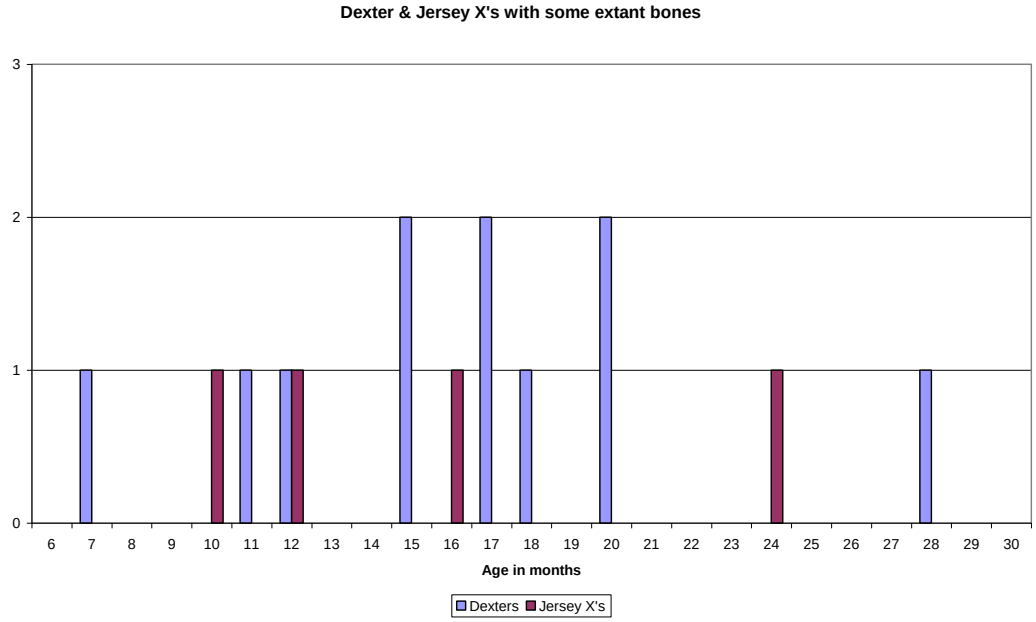


Figure 3: 9a Astragalus measurements of Dexter young males

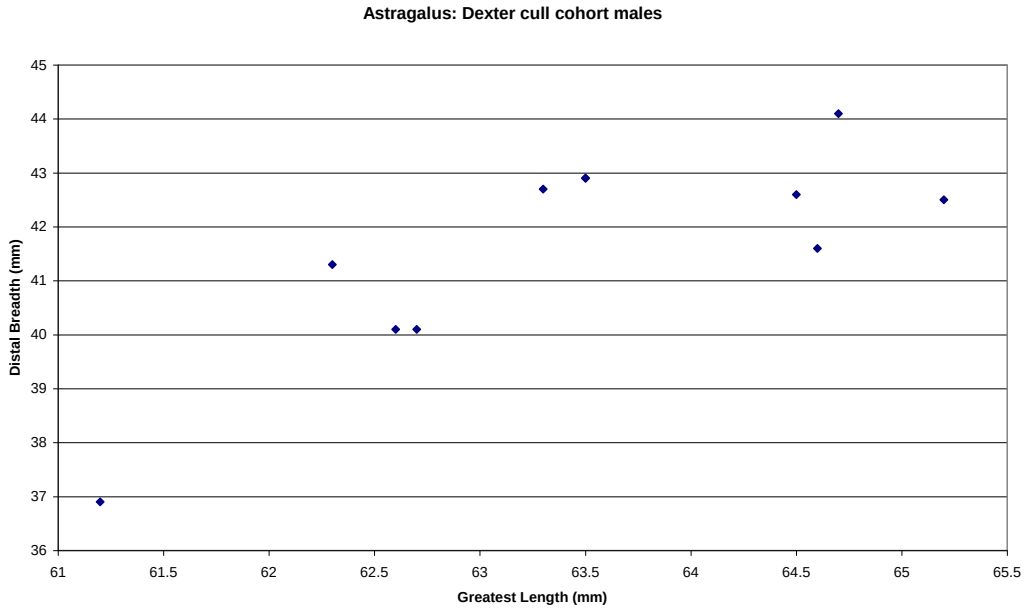


Figure 3: 9b Astragalus measurements, young Dexter males and adult bulls

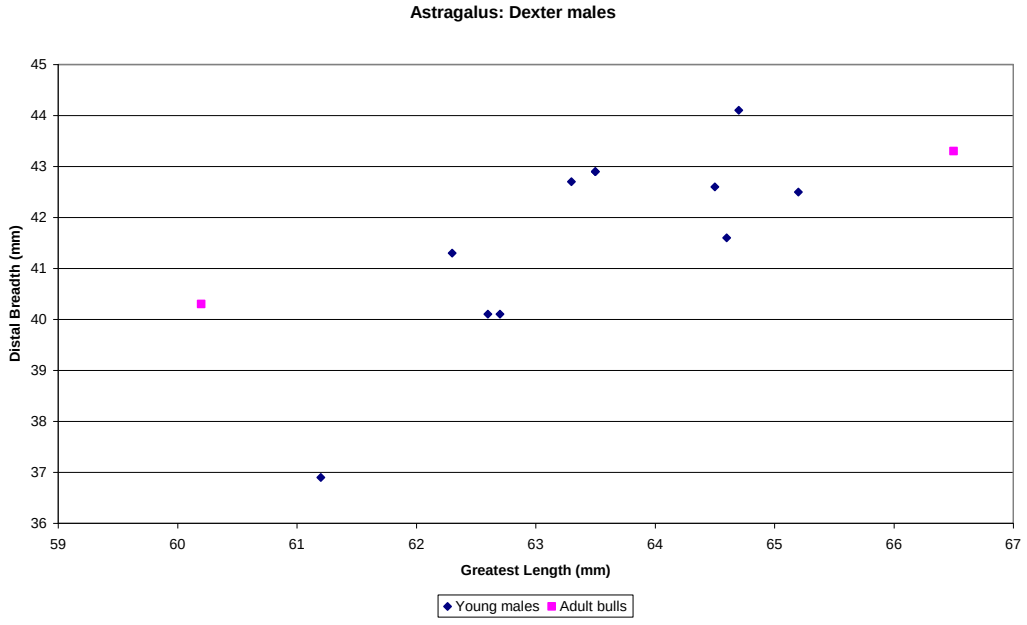


Figure 3: 9c Astragalus measurements Dexter males entire and castrate

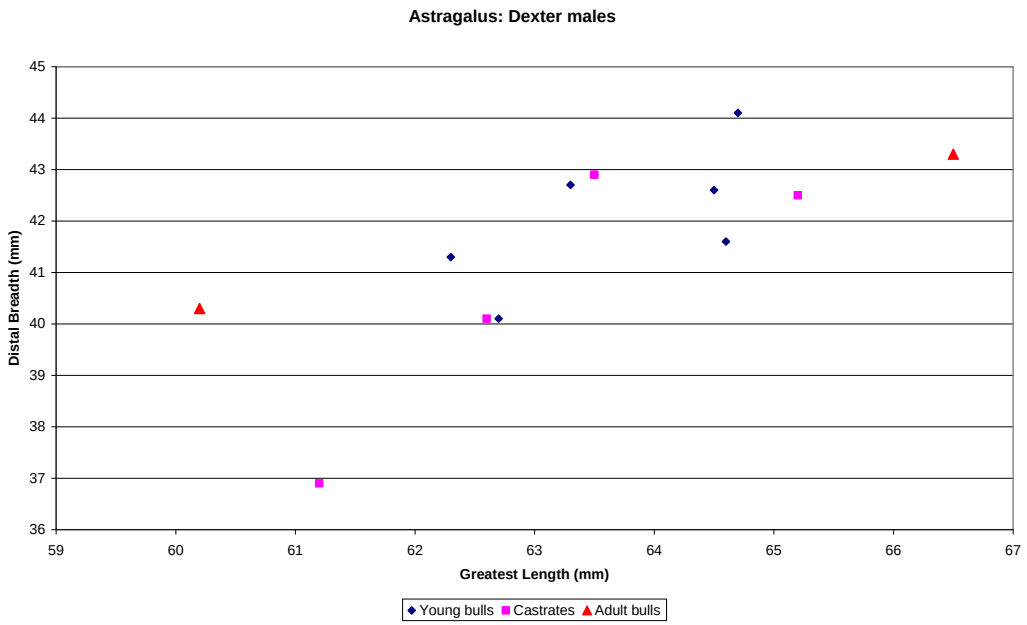


Figure 3: 9d Astragalus measurements young Dexter and Jersey cross males

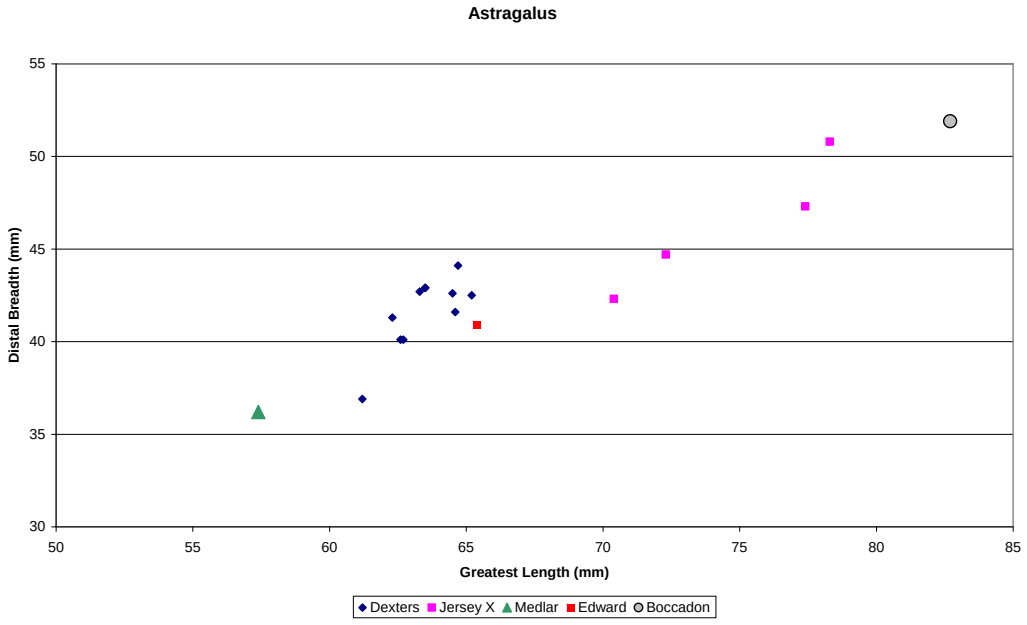


Figure 3: 9e Astragalus measurements including heifer Dusty

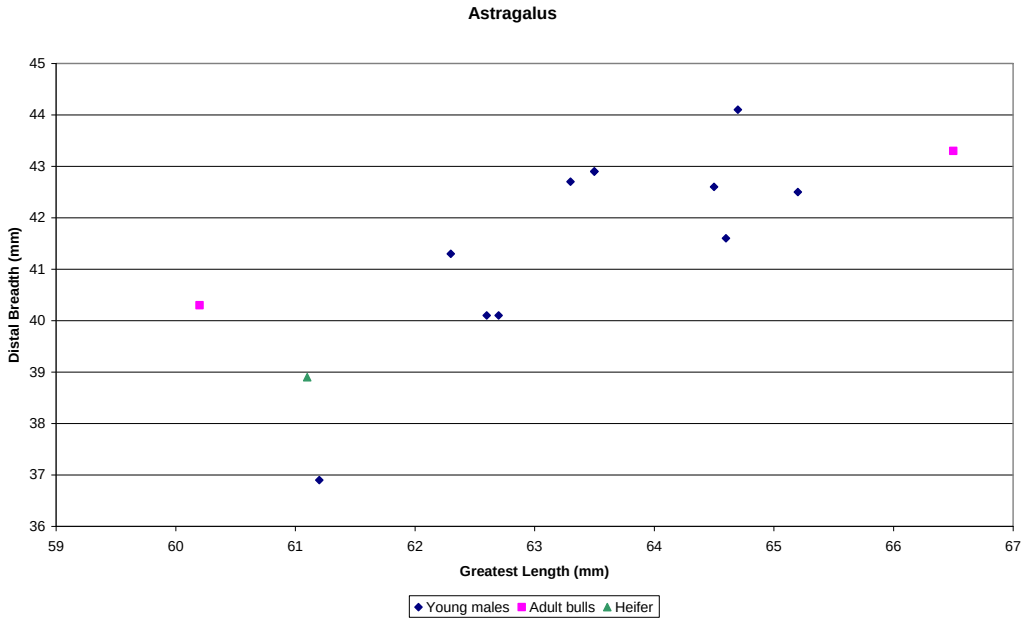


Figure 3: 10a Humerus distal trochlea measurements, Dexter males entire and castrate

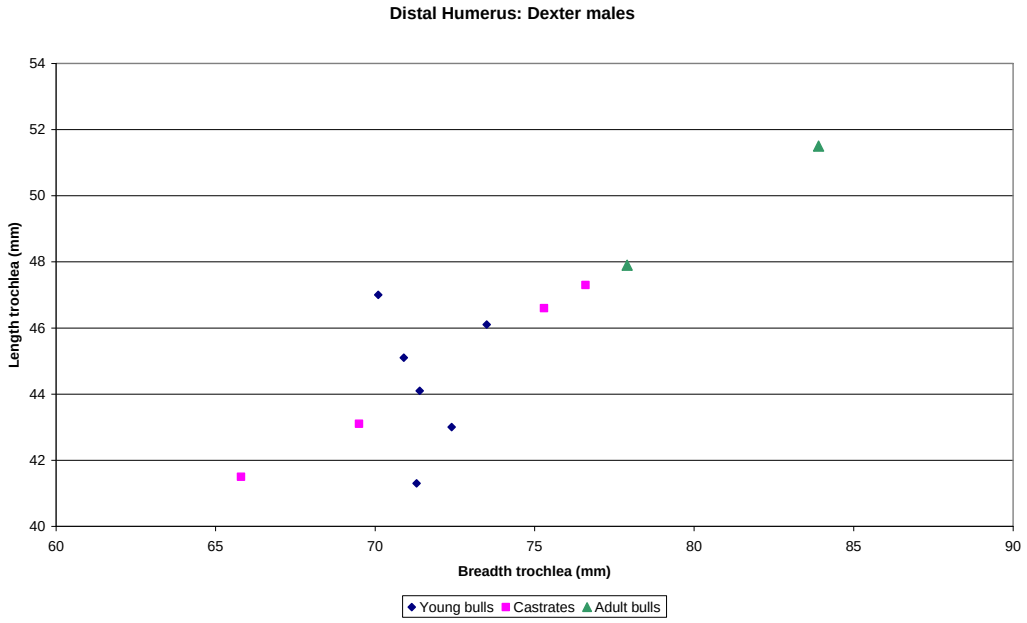


Figure 3: 10b Humerus distal trochlea measurements, non-short and short males

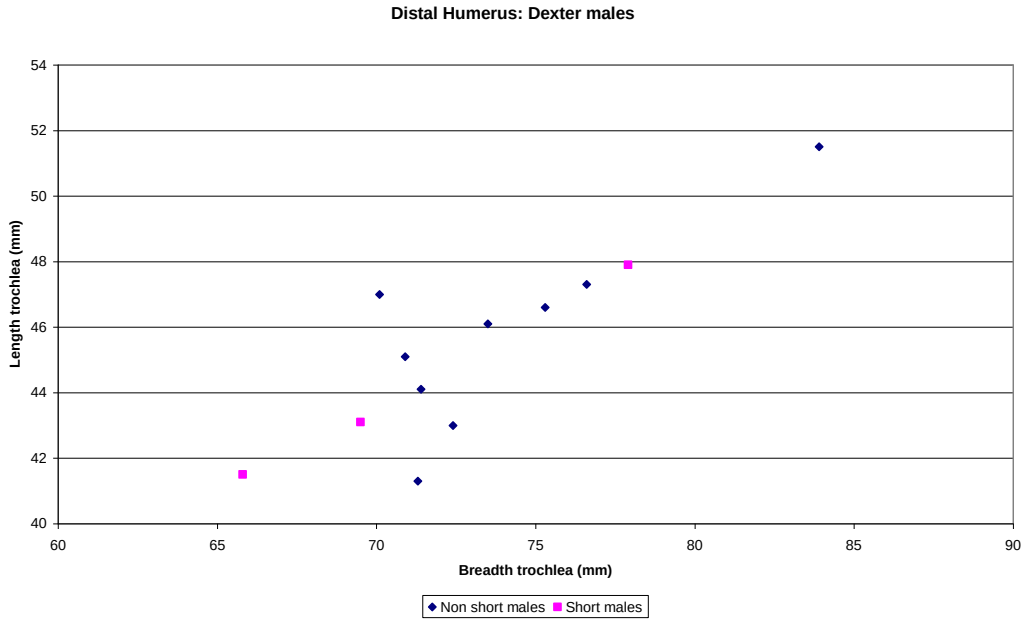


Figure 3: 10c Humerus distal trochlea measurements, young Dexter and Jersey X males

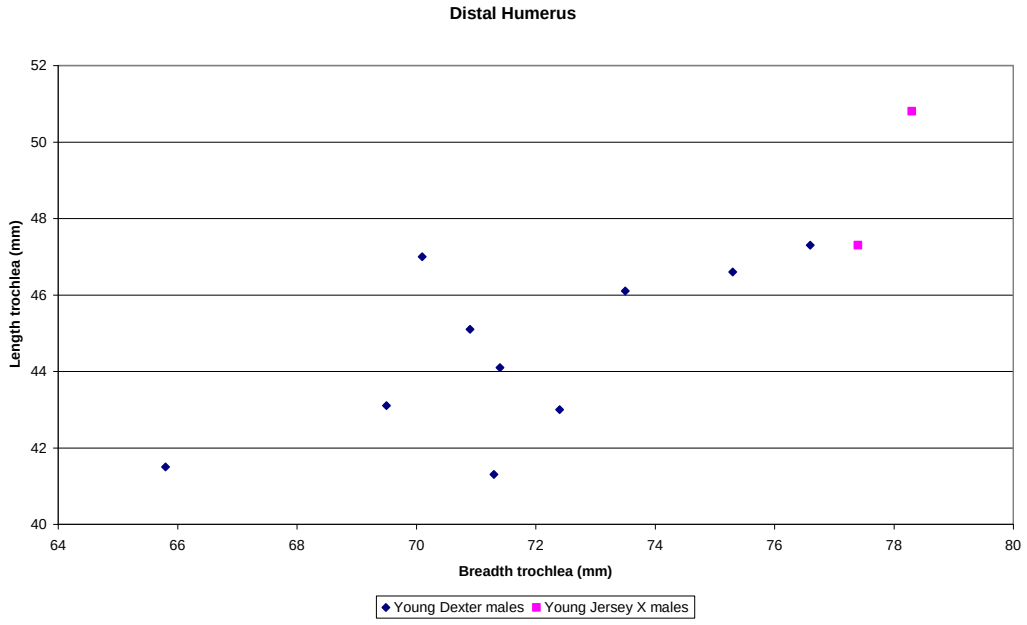


Figure 3: 10d Humerus distal trochlea measurements, heifer Dusty compared with Dexter males

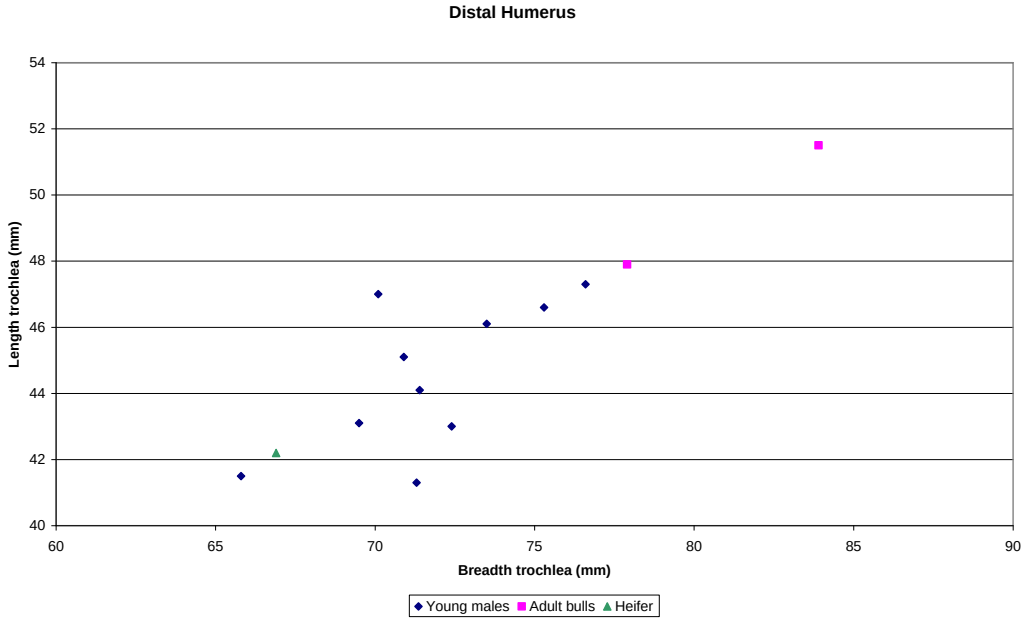


Figure 3: 11a Green Shiel calf metatarsals

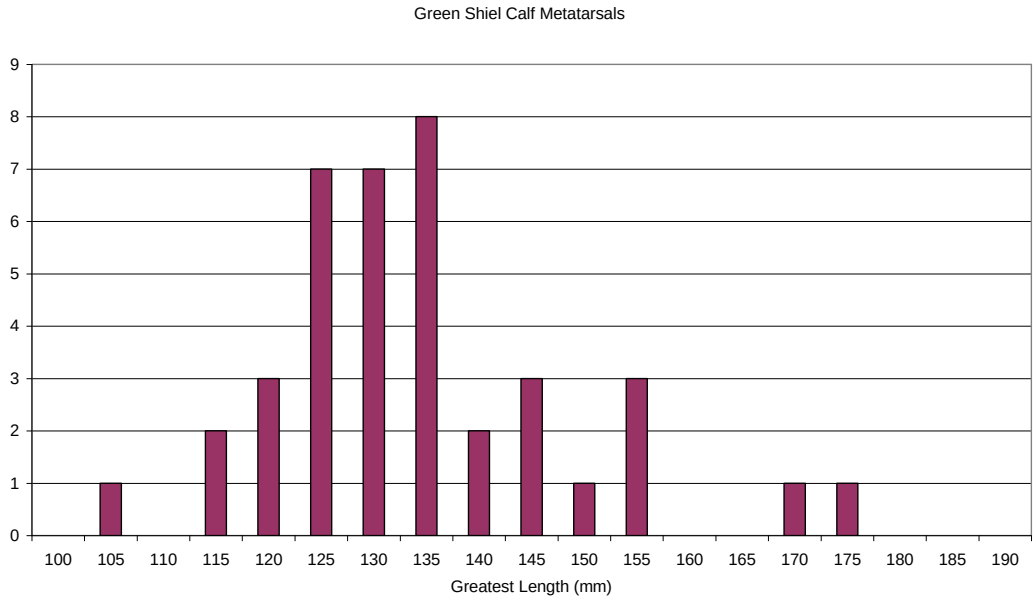


Figure 3: 11b Green Shiel calf metatarsals with comparanda

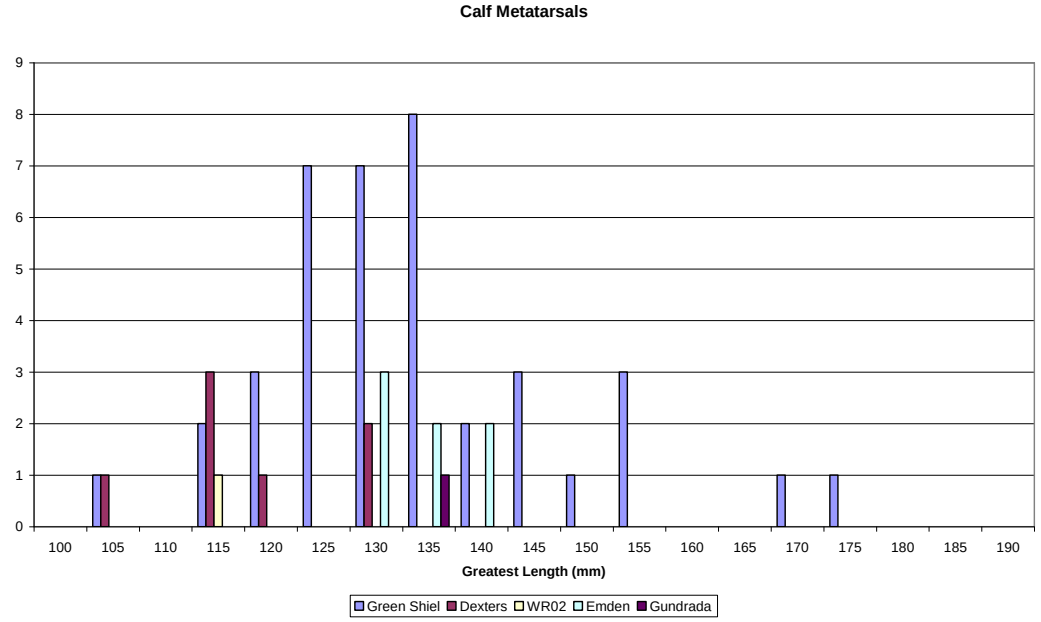


Figure 3: 12a Emden and Dexter calf scapulae

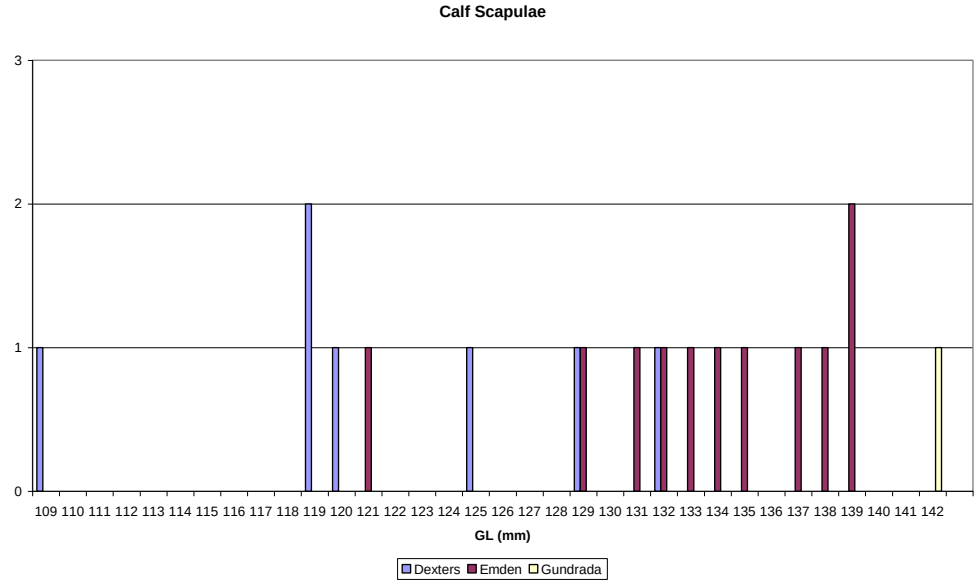


Figure 3: 12b Emden and Dexter calf humeri

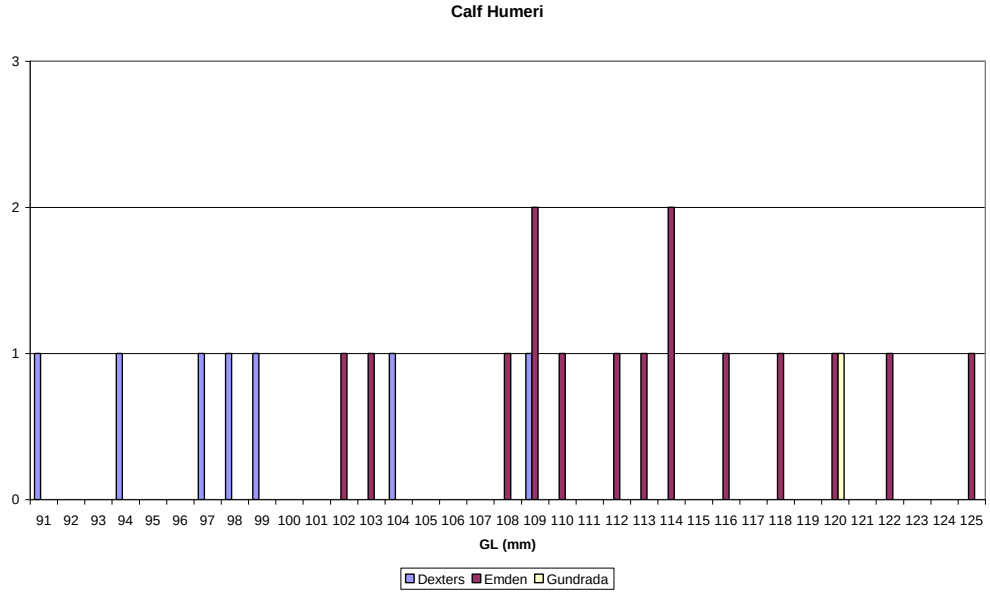


Figure 3: 12c Emden and Dexter calf radii

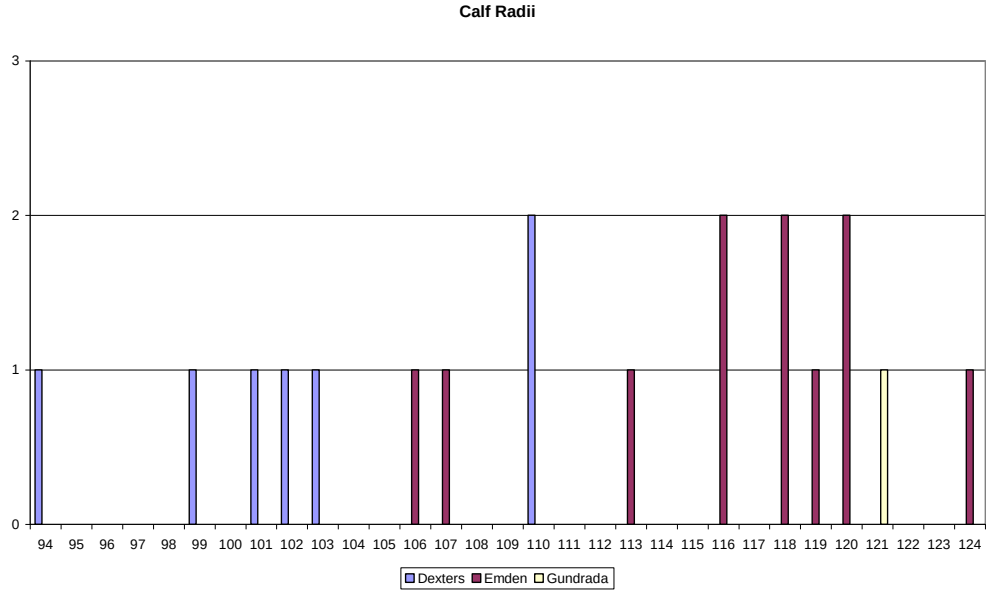


Figure 3: 12d Emden and Dexter calf femora

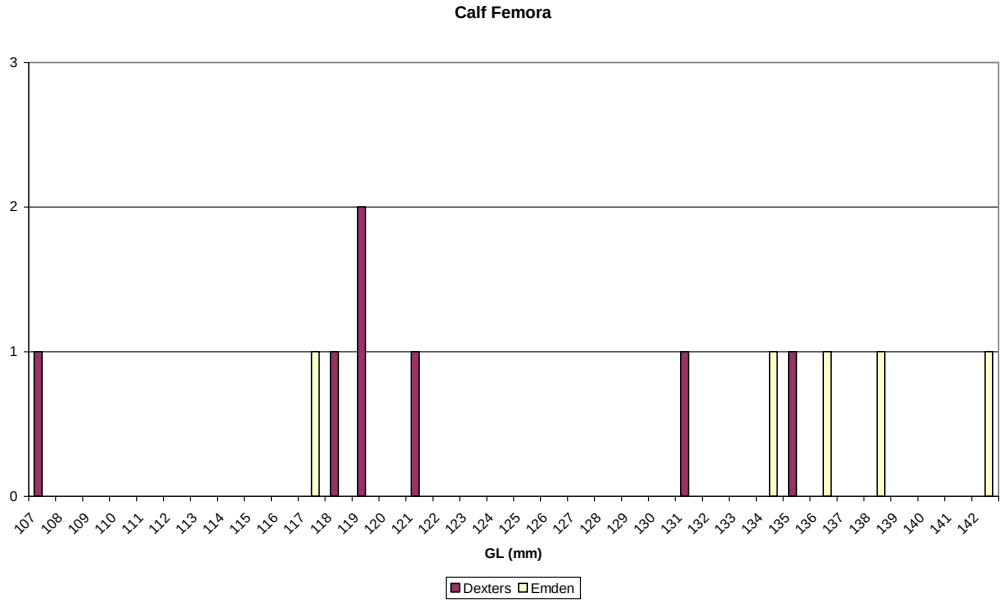


Figure 3: 12e Emden and Dexter calf tibiae

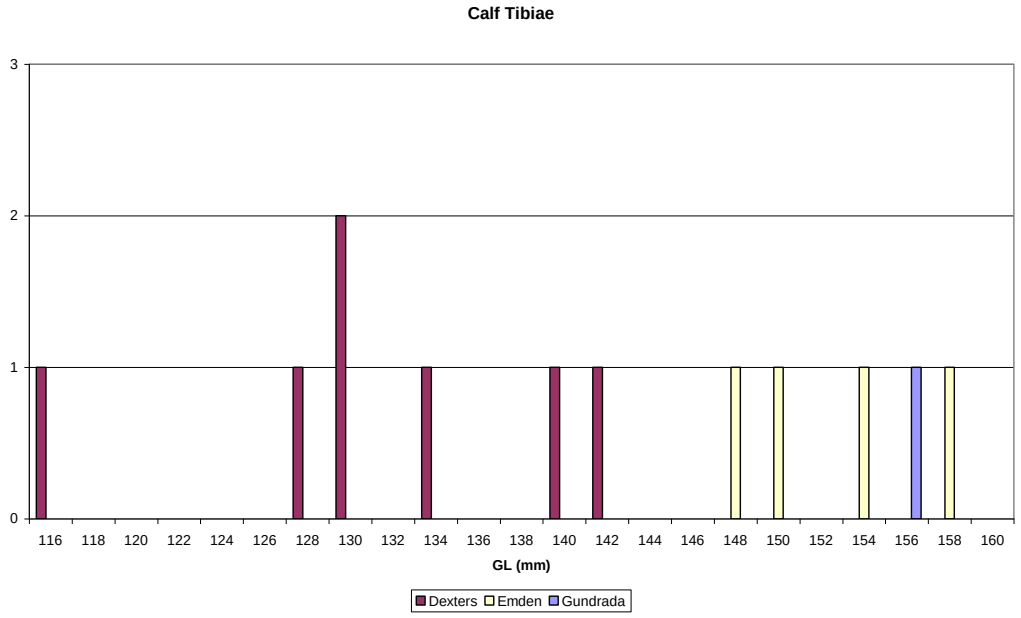


Figure 3: 13 Emden cattle withers heights

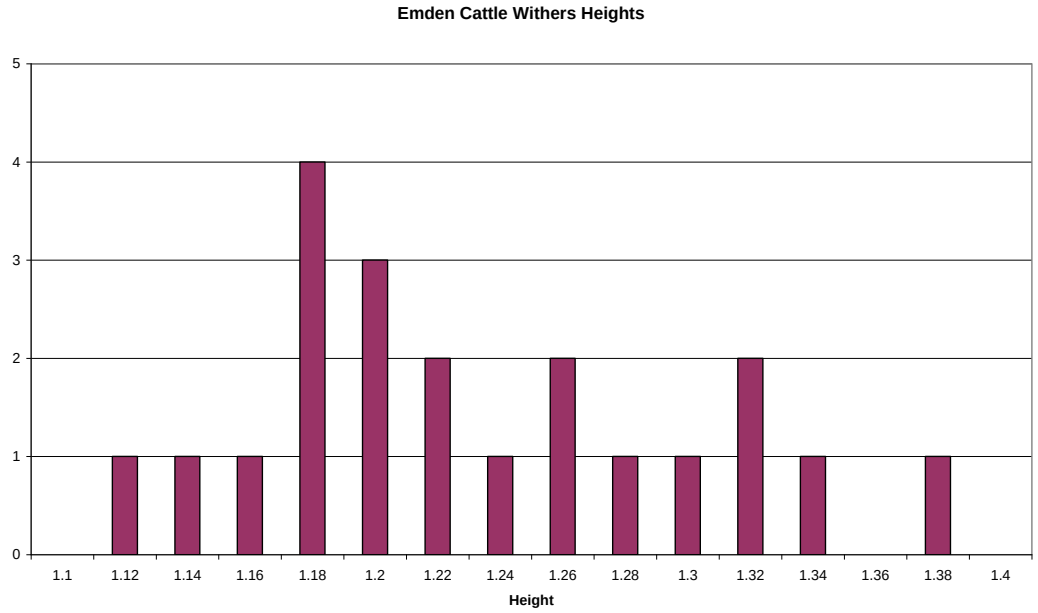


Figure 4: 1 Lactation Curve (after Board on Agriculture 2000, 44)

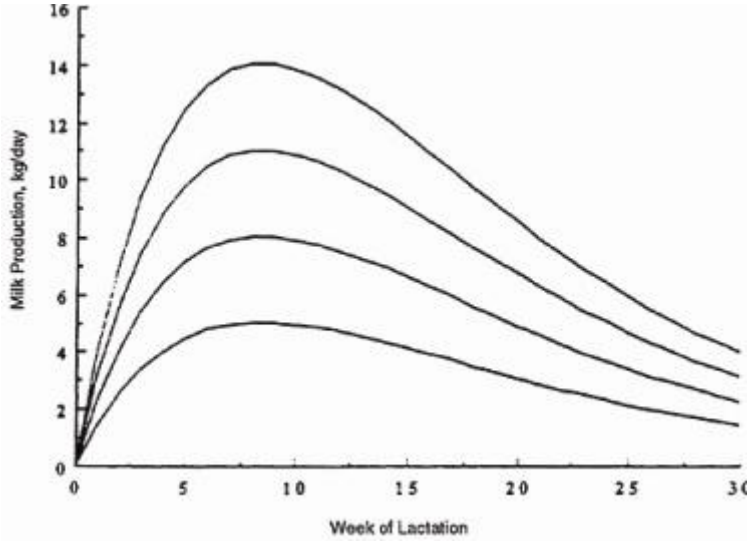


Figure 4: 2 Vycanny Dexter Herd: Distribution of Days in Milk

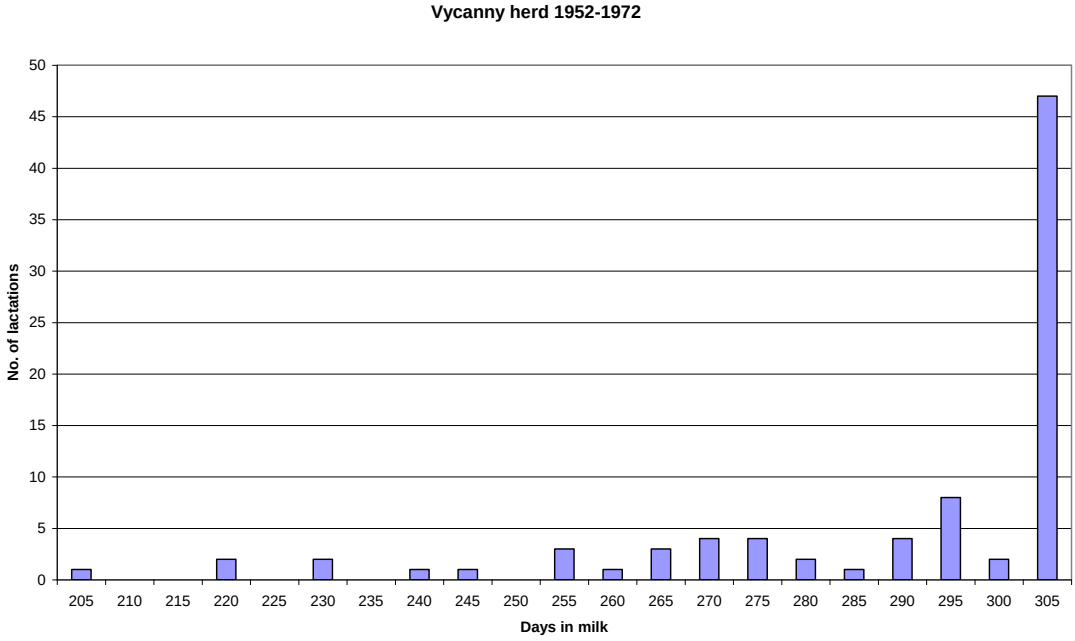


Figure 4: 3 Heights of normal and dwarf Jersey cows in one American herd

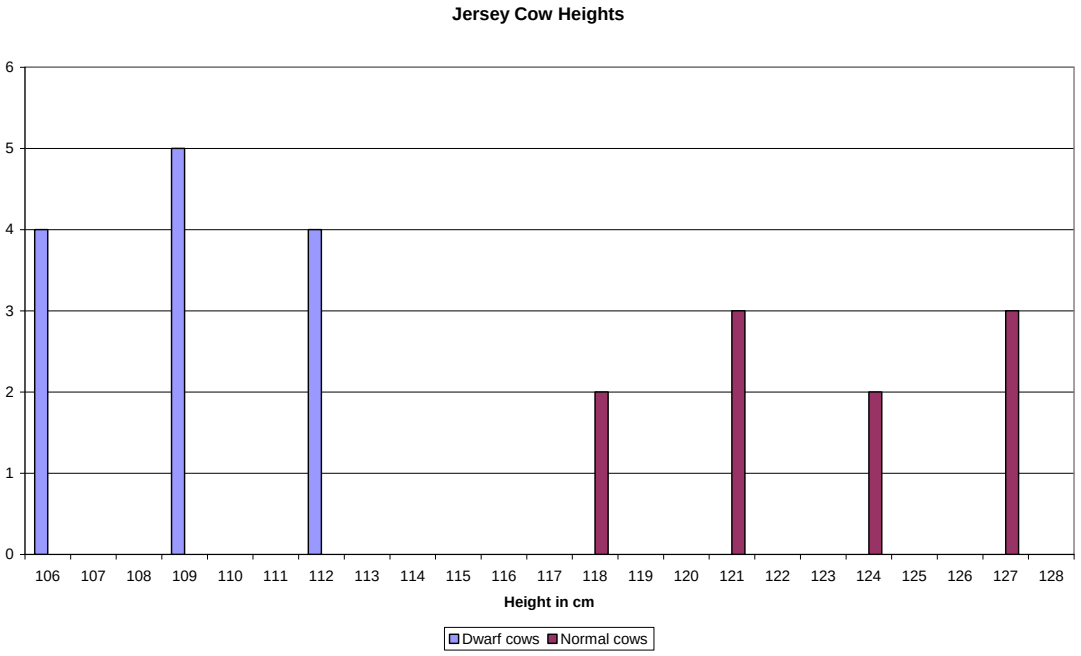


Figure 4: 4 Vycanny Herd, Annual recorded lactations

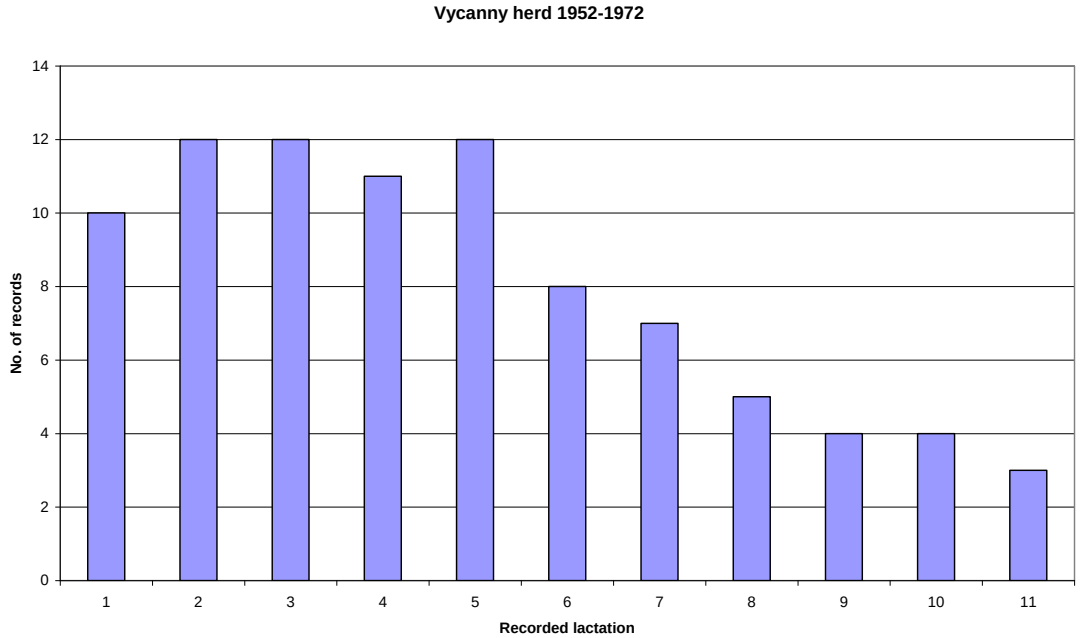


Figure 4: 5a Vycanny cows, humerus distal trochlea measurements

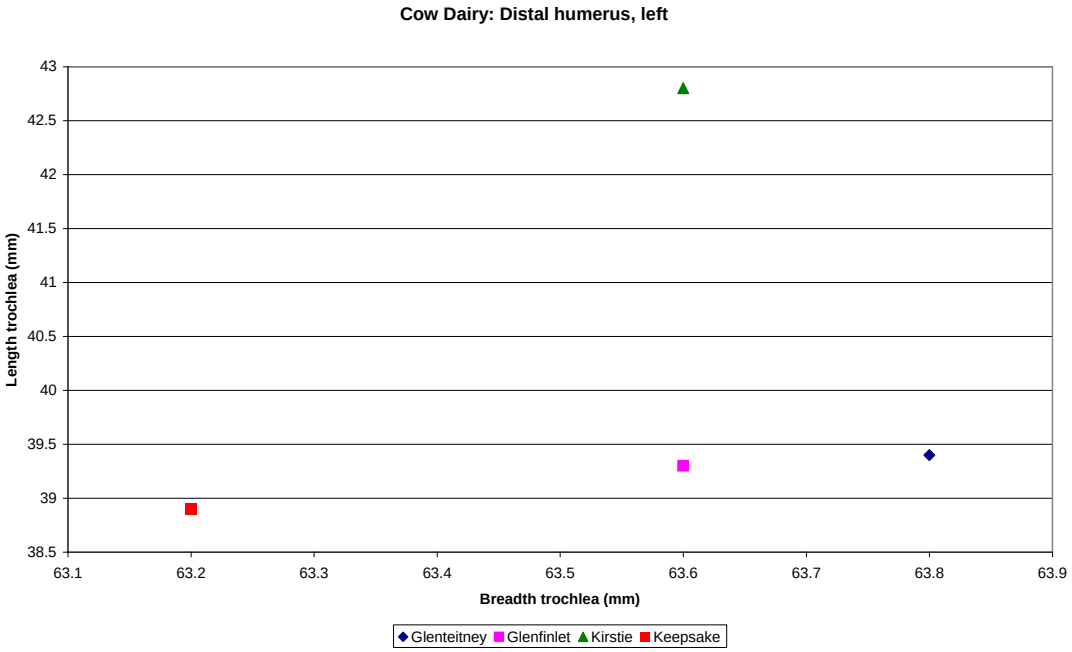


Figure 4: 5b Vycanny cows and two bulls, humerus distal trochlea measurements

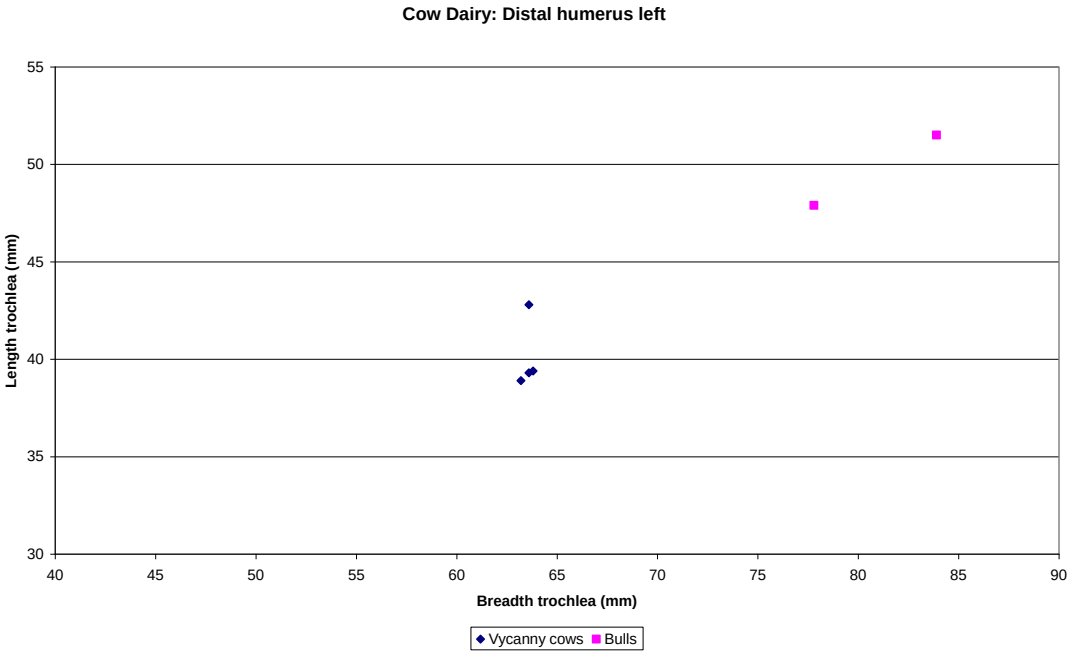


Figure 4: 5c Vycanny cows, distal tibia measurements

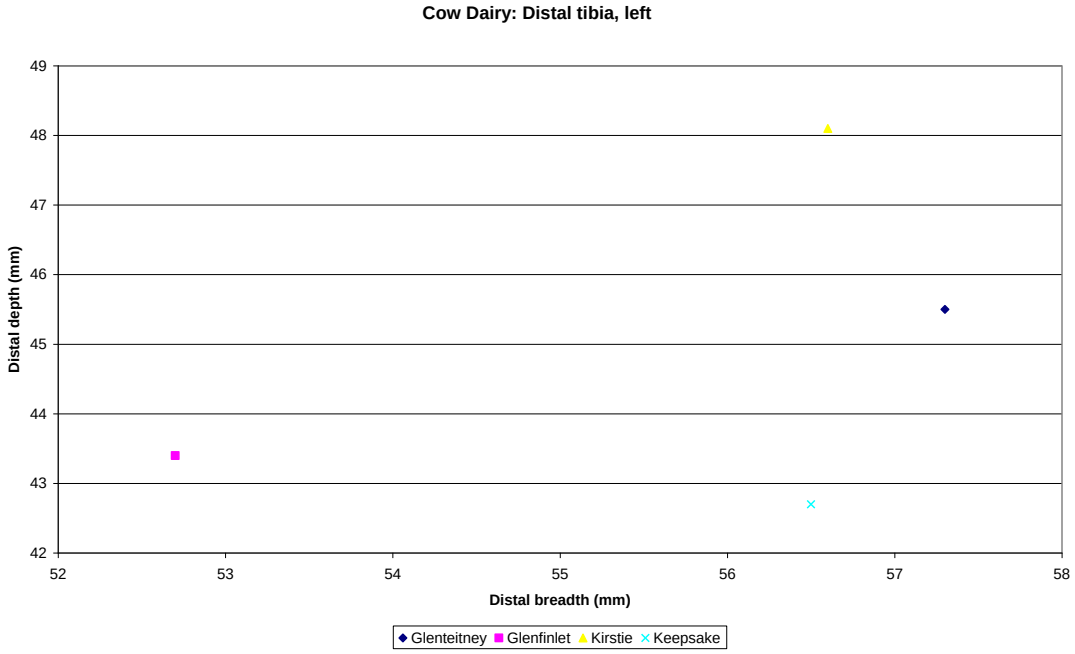


Figure 4: 5d Vycanny cows and two bulls, distal tibia

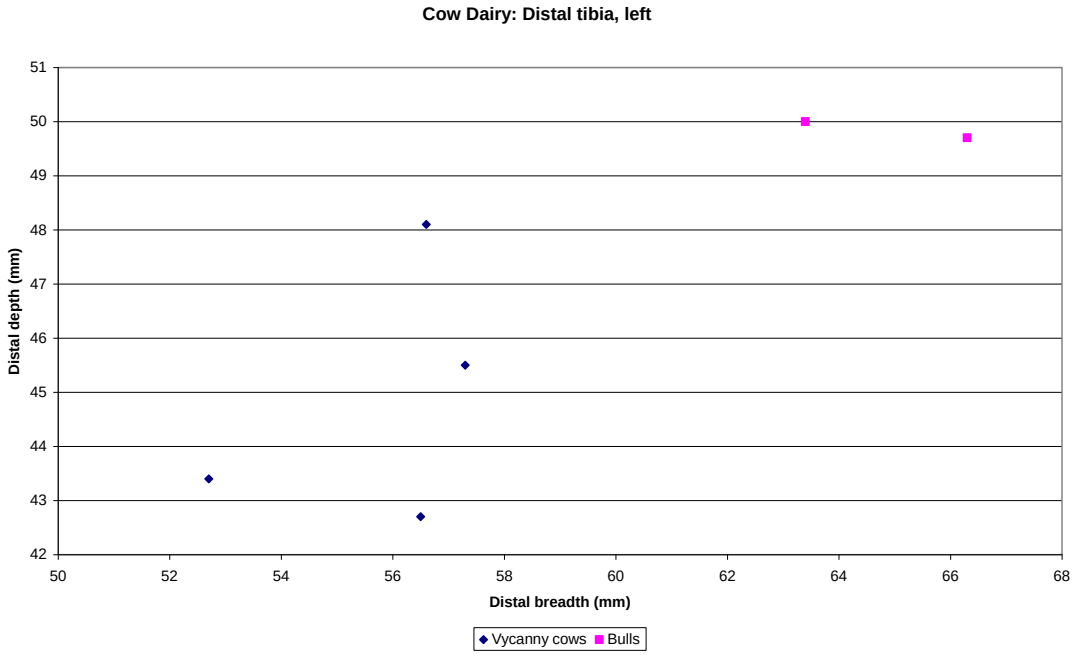


Figure 4: 6 Estimated cattle withers heights for Vindolanda and South Shields Roman forts

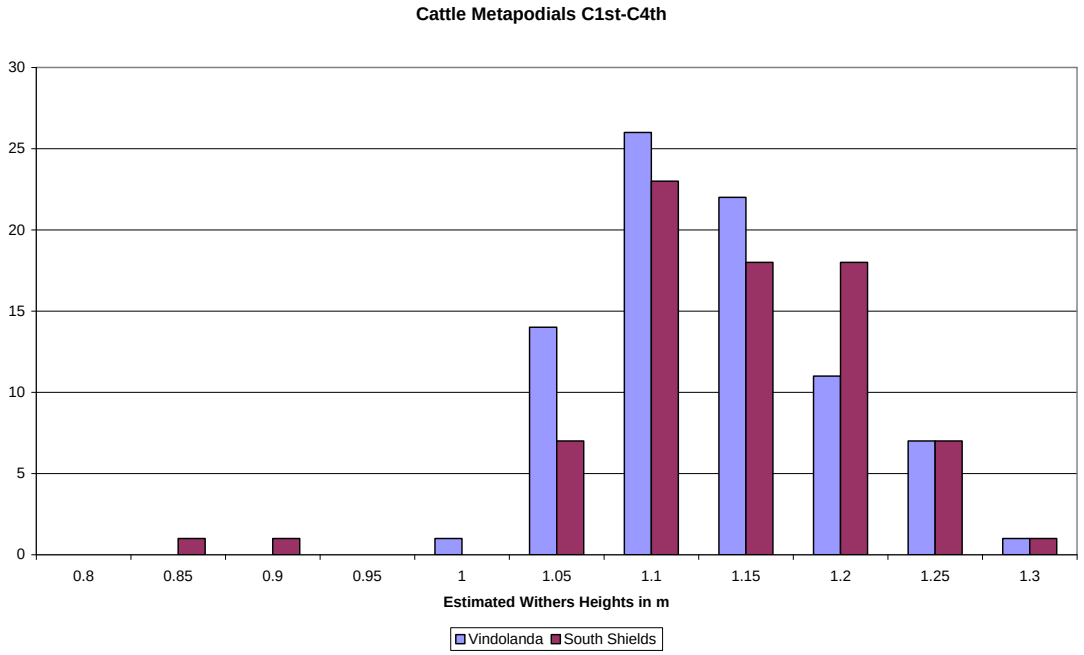


Figure 4: 7 Green Shiel and Vycanny cows, distal humerus

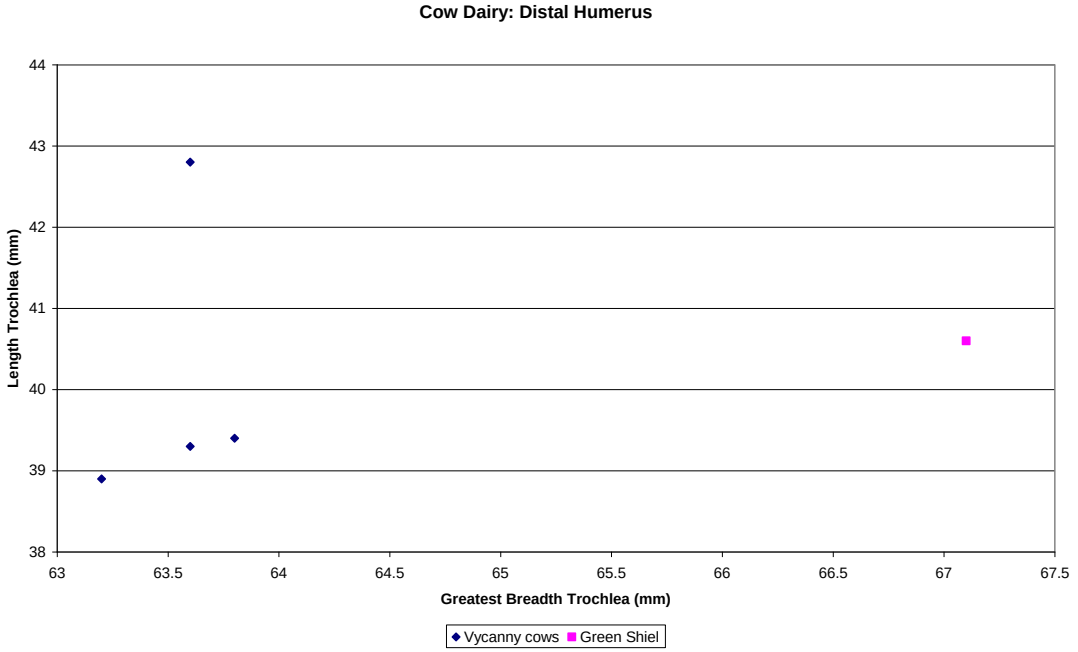


Figure 4: 8 Green Shiel and Vycanny cows, distal tibia

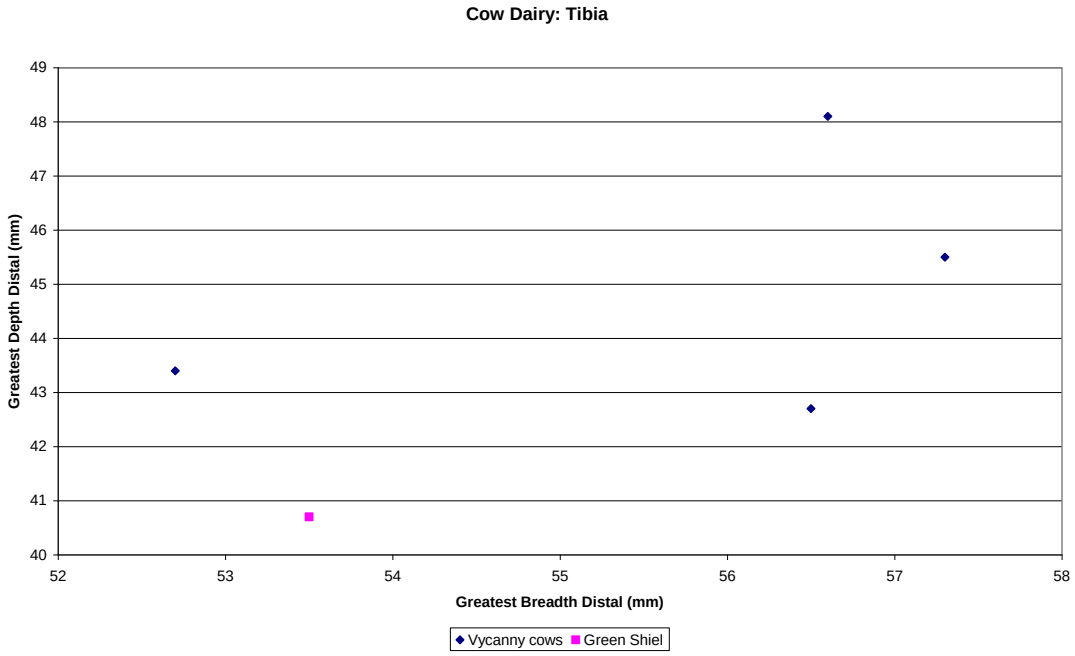


Figure 5: 1 Mortality of cows in reference collection and Zanfara cows not in reference collection

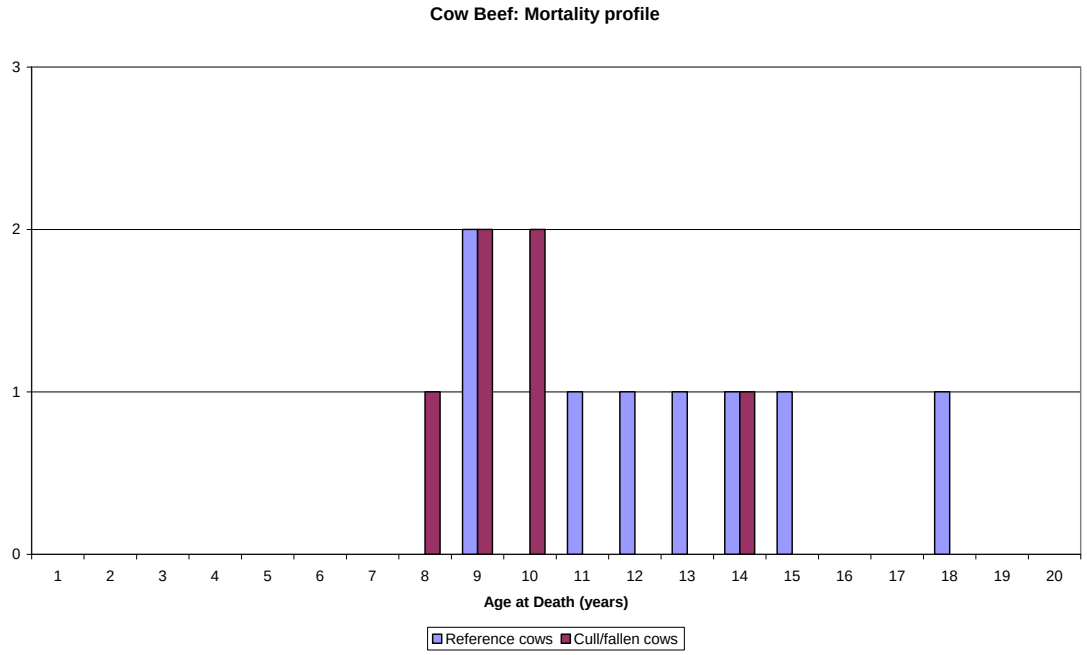


Figure 5: 2 Calendar age at death: Halle collection, Dexter cows and adult bulls

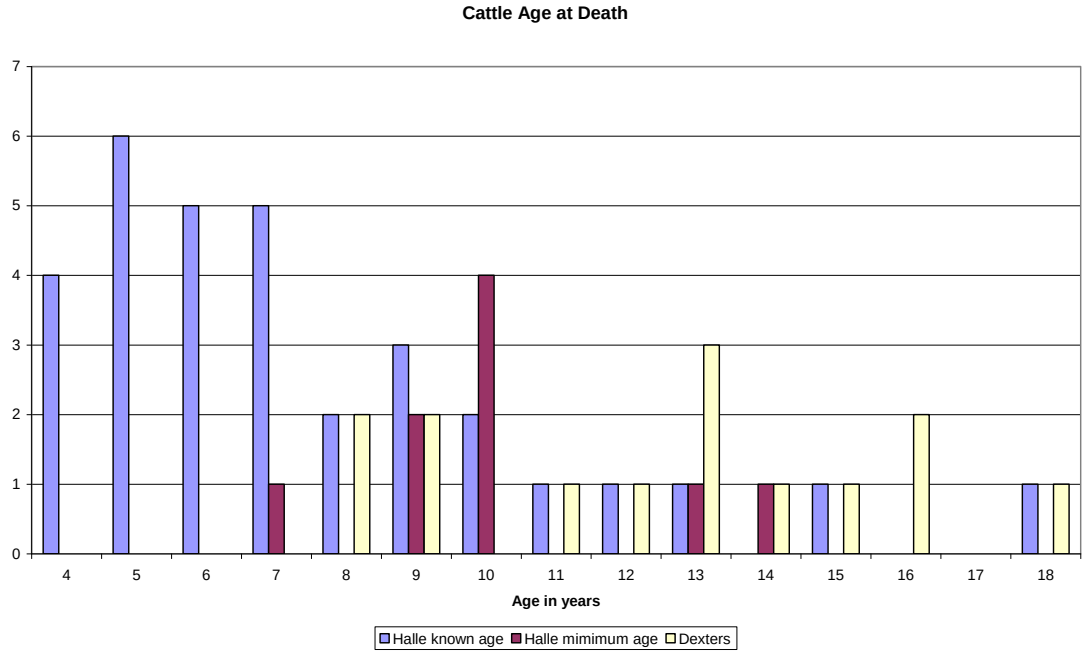


Figure 5: 3 MWS for Halle collection, Dexter cows and adult bulls

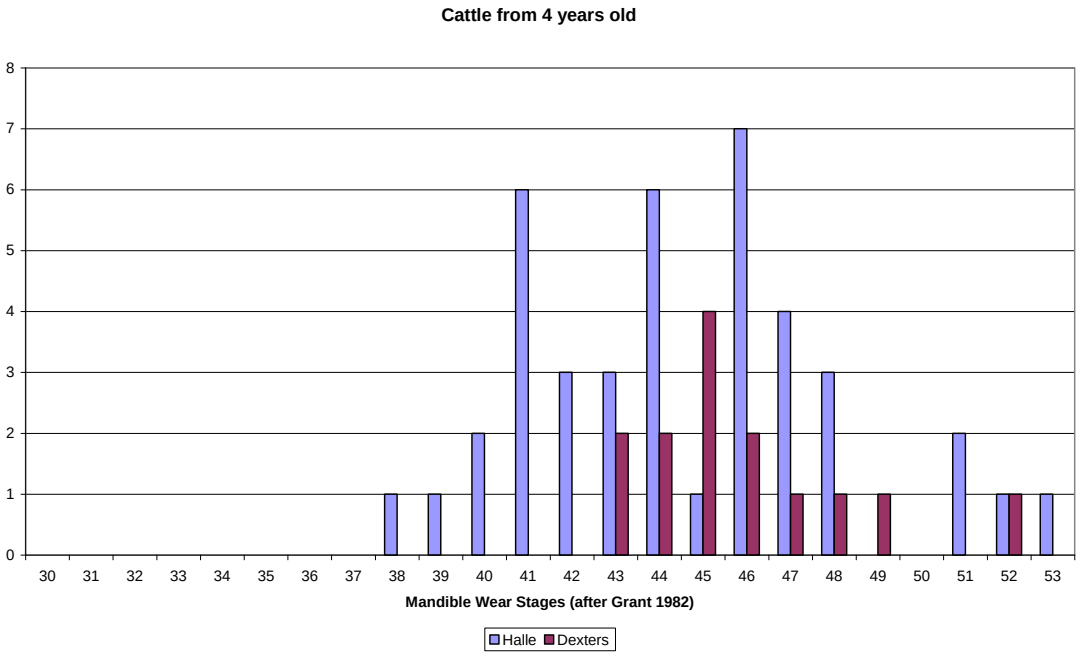


Figure 5: 4a Suckler cows, humerus distal trochlea measurements

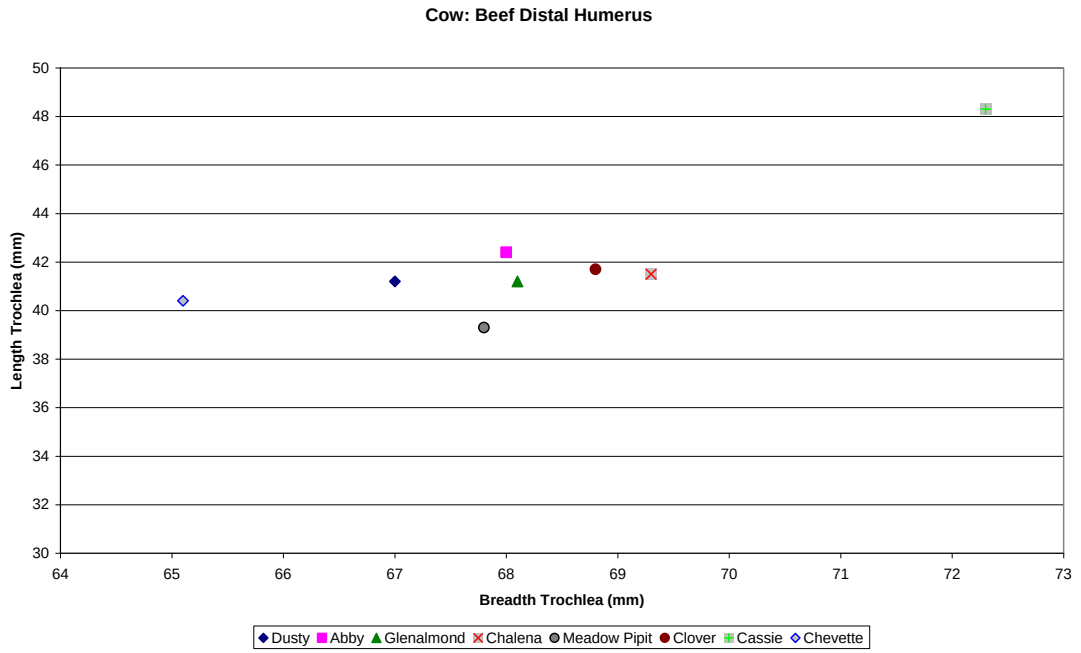


Figure 5: 4b All cows and adult bulls, humerus distal trochlea measurements

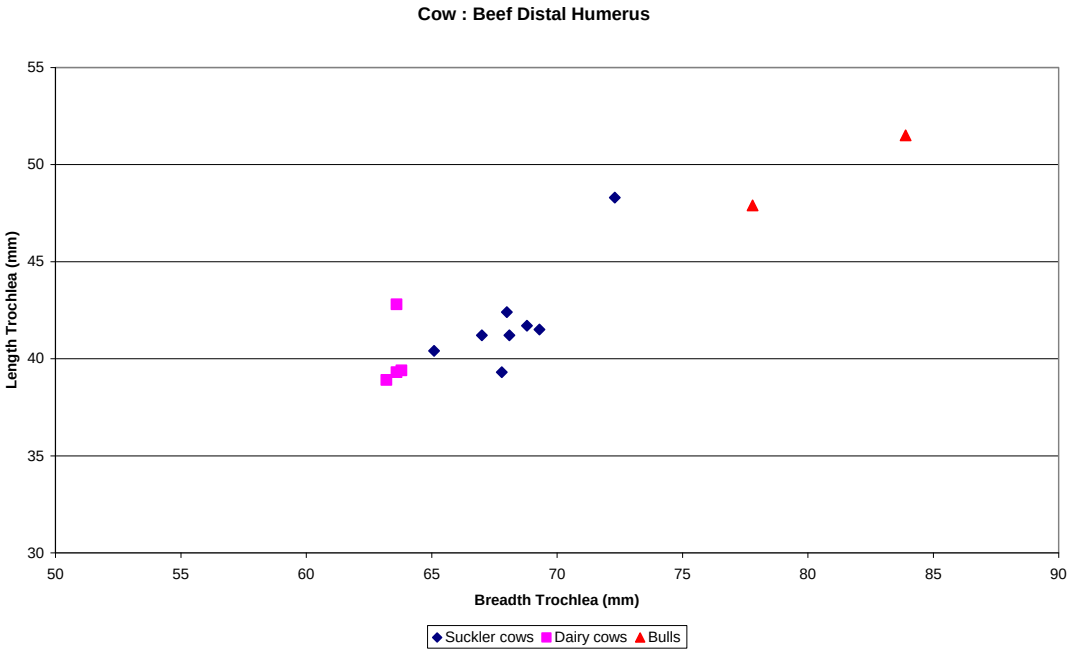


Figure 5: 5a Suckler cows, distal tibia measurements

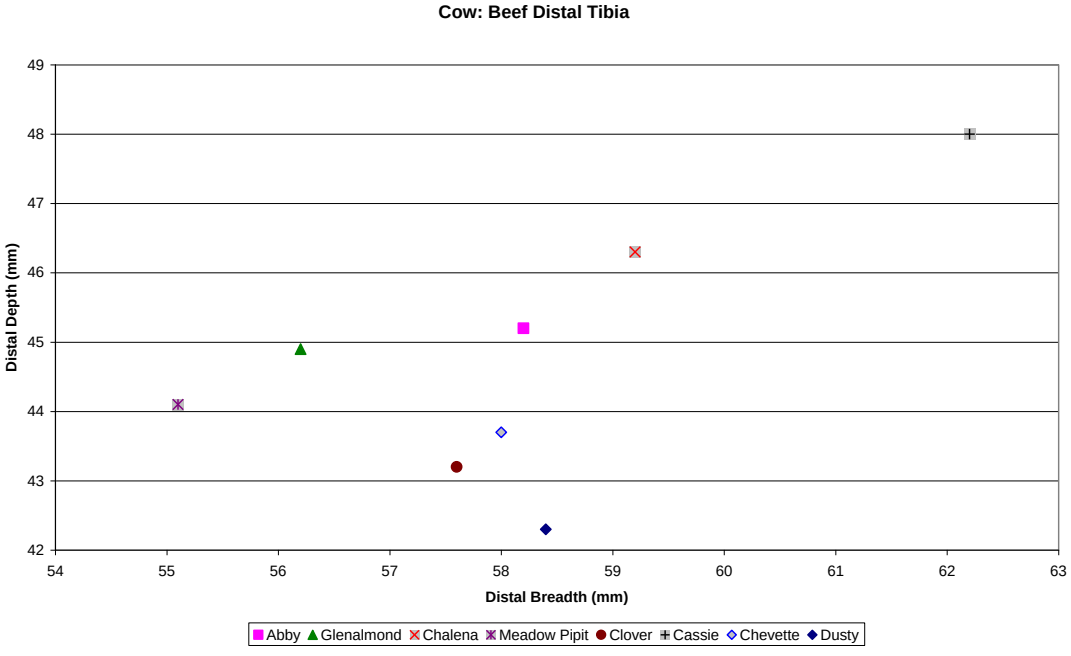


Figure 5: 5b All cows and adult bulls, distal tibia measurements

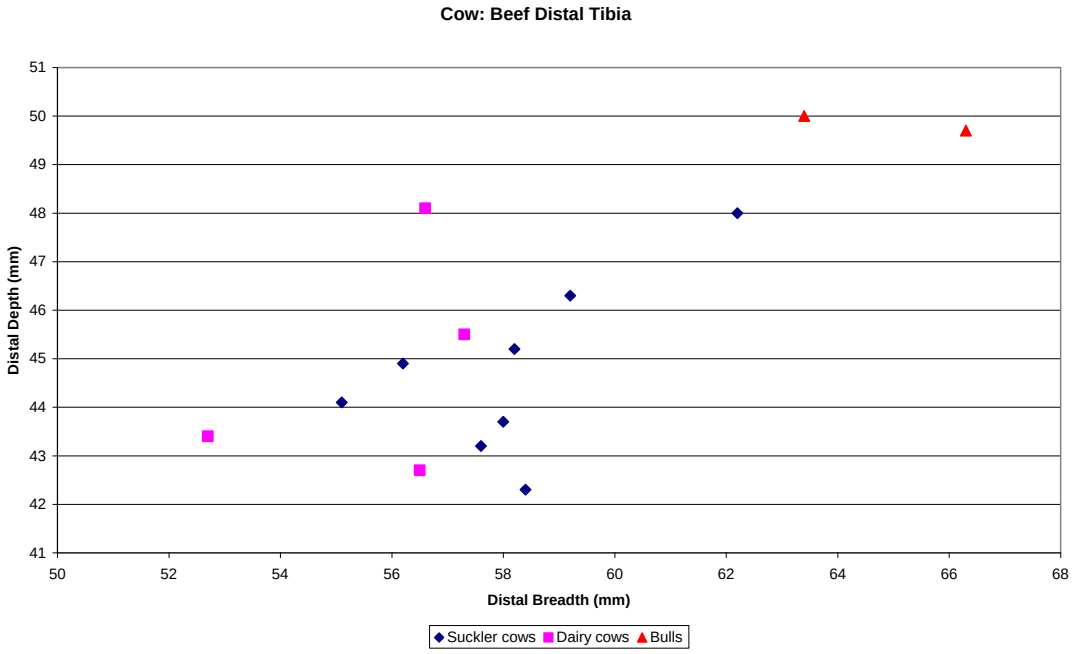


Figure 5:6a Suckler cows, astragalus measurements

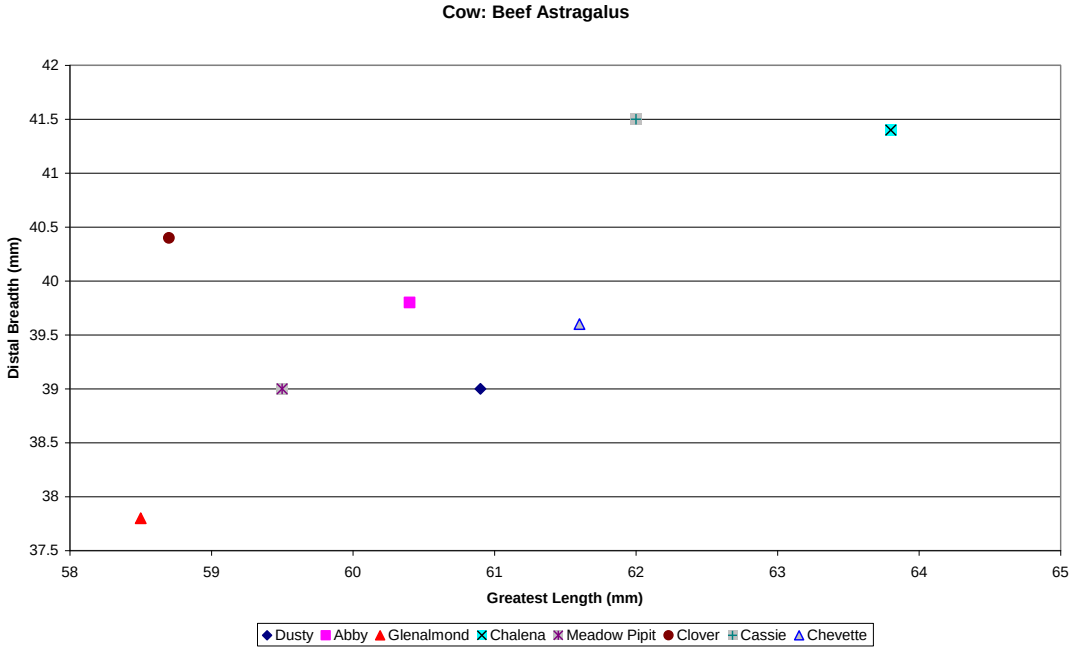


Figure 5: 6b Comparison of all cows and adult bulls, astragalus measurements

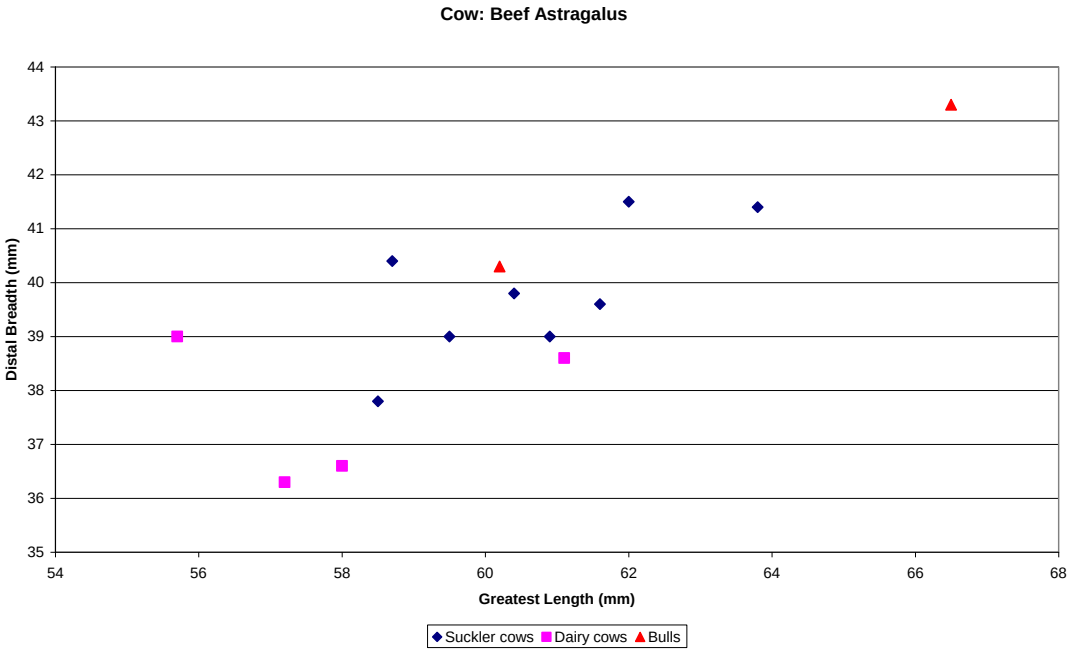


Figure 5: 6c Comparison of all cows adult and immature males, astragalus measurements

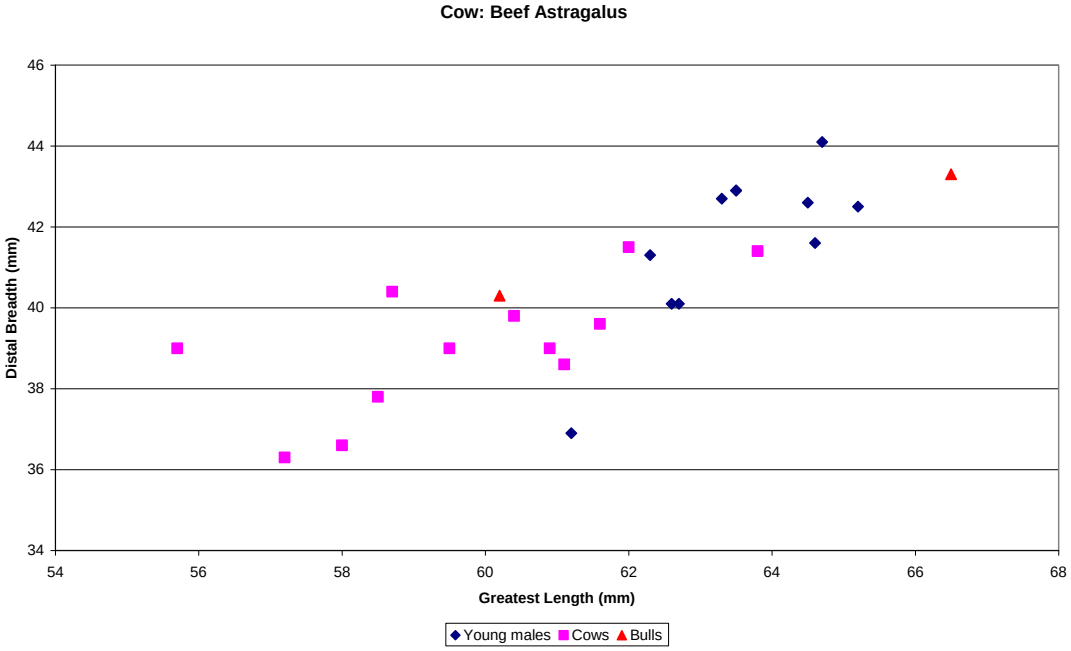


Figure 5: 7 Comparsion of withers heights of short and non-short Dexter and Jersey cows

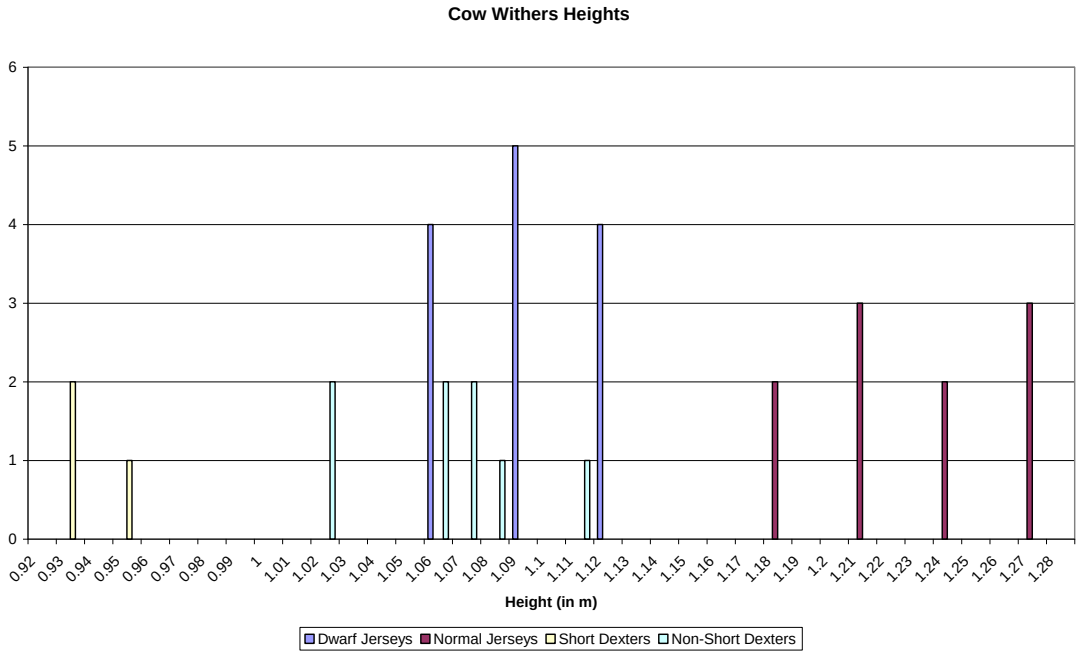


Figure 5: 8a Grimes Graves and Dexters, estimated withers heights

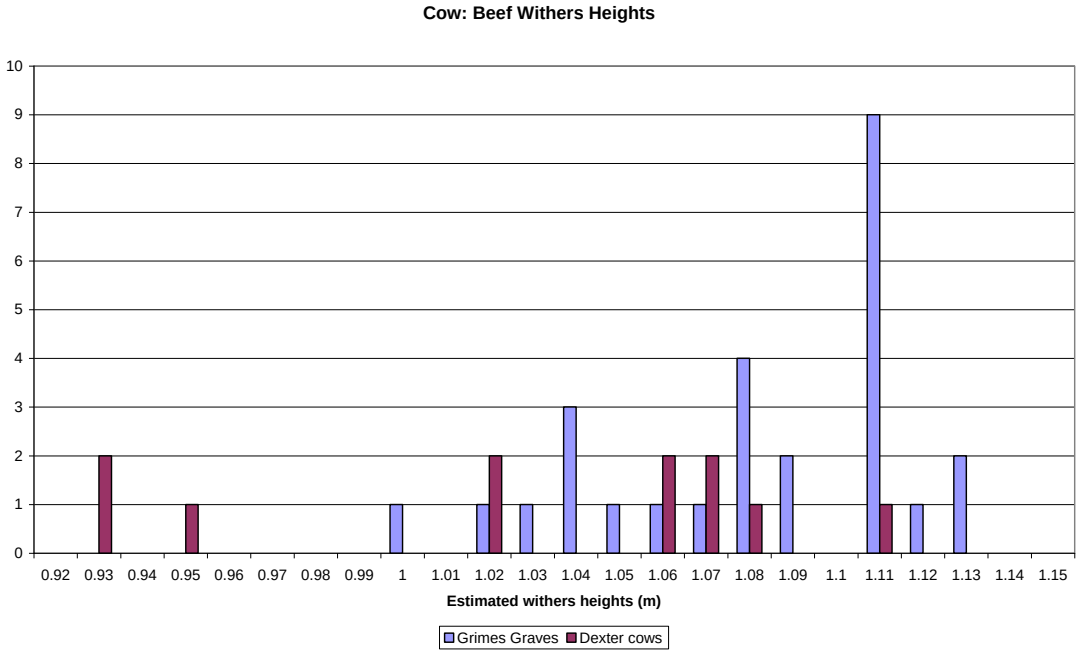


Figure 5: 8b Grimes Graves and Dexter Distal Breadth metacarpals

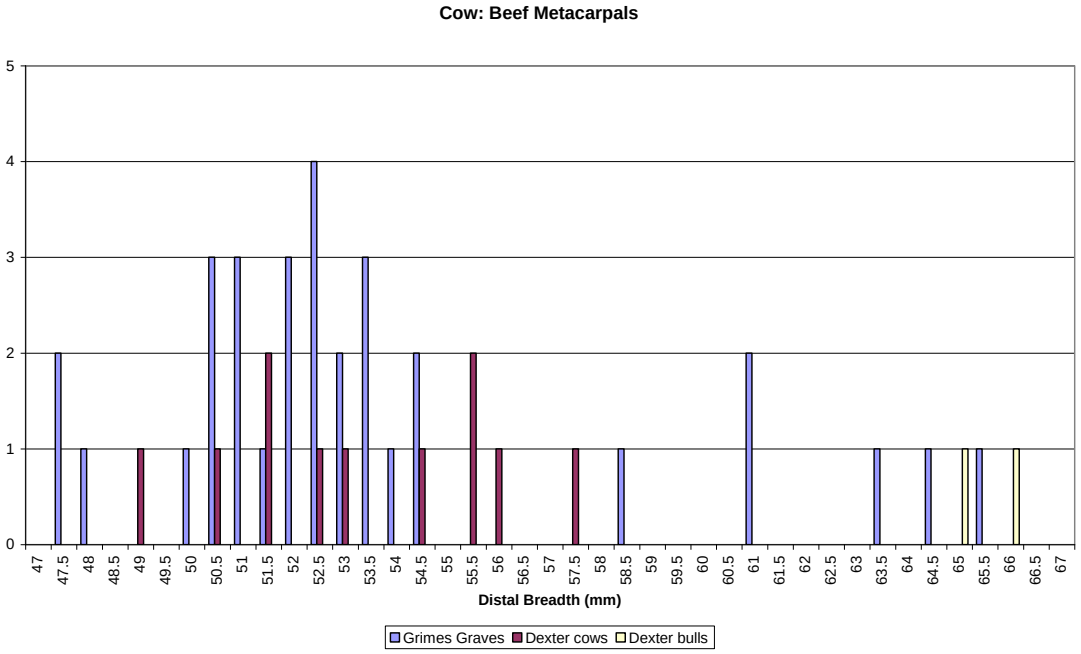


Figure 5: 8c Grimes Graves and Dexters, astragali measurements

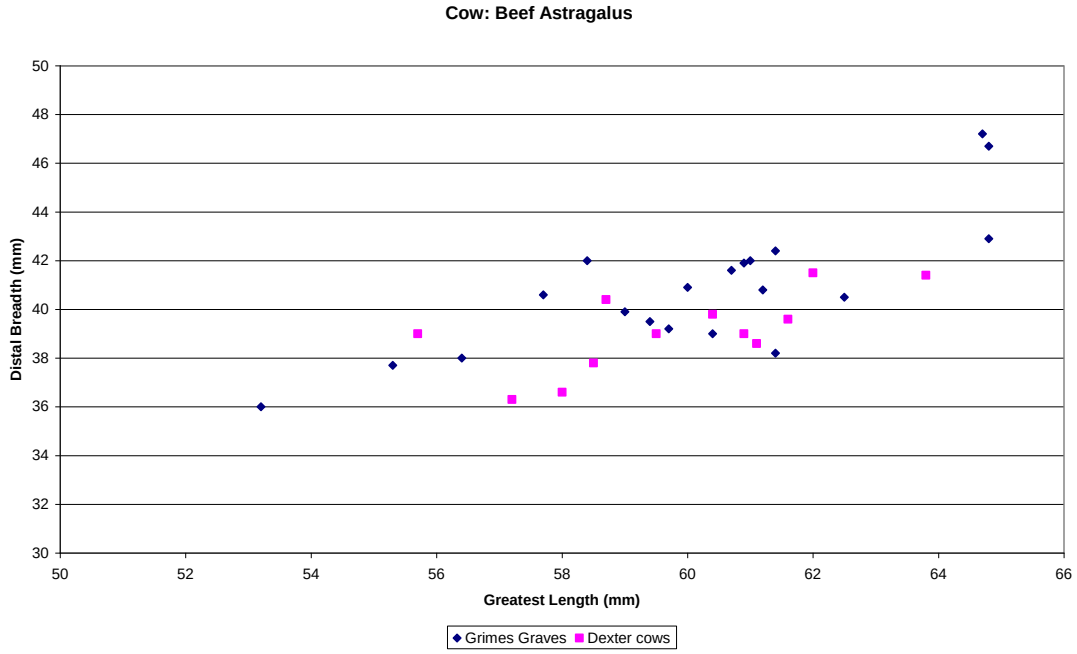


Figure 5: 9a C4th Lincoln and Dexters, estimated withers heights

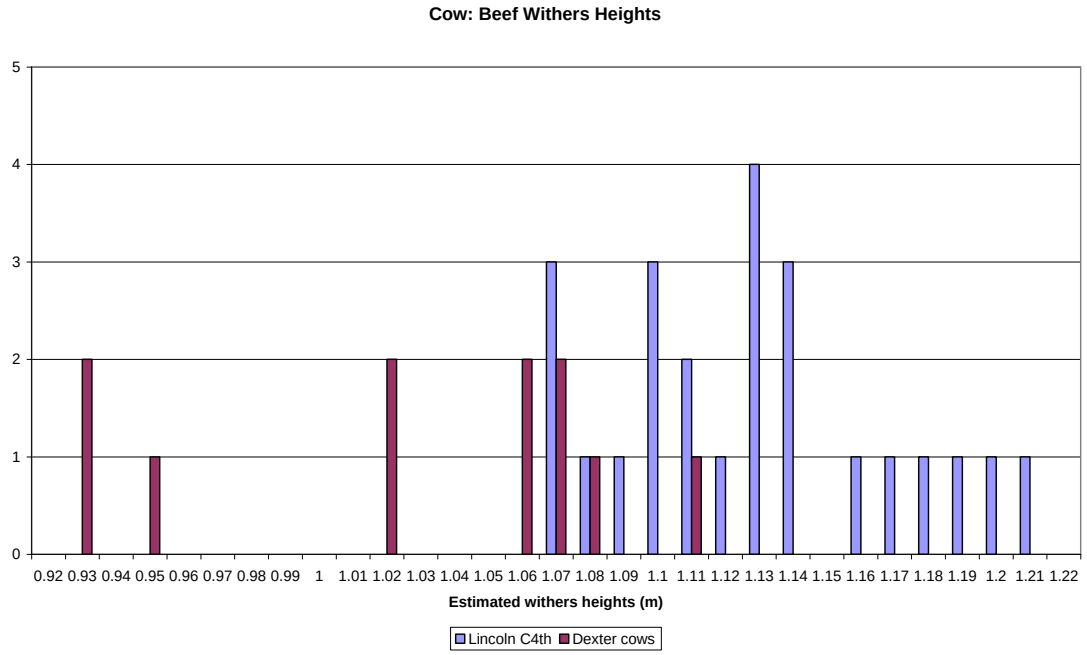


Figure 5: 9b C4th Lincoln and Dexters, Distal Breadth metacarpals

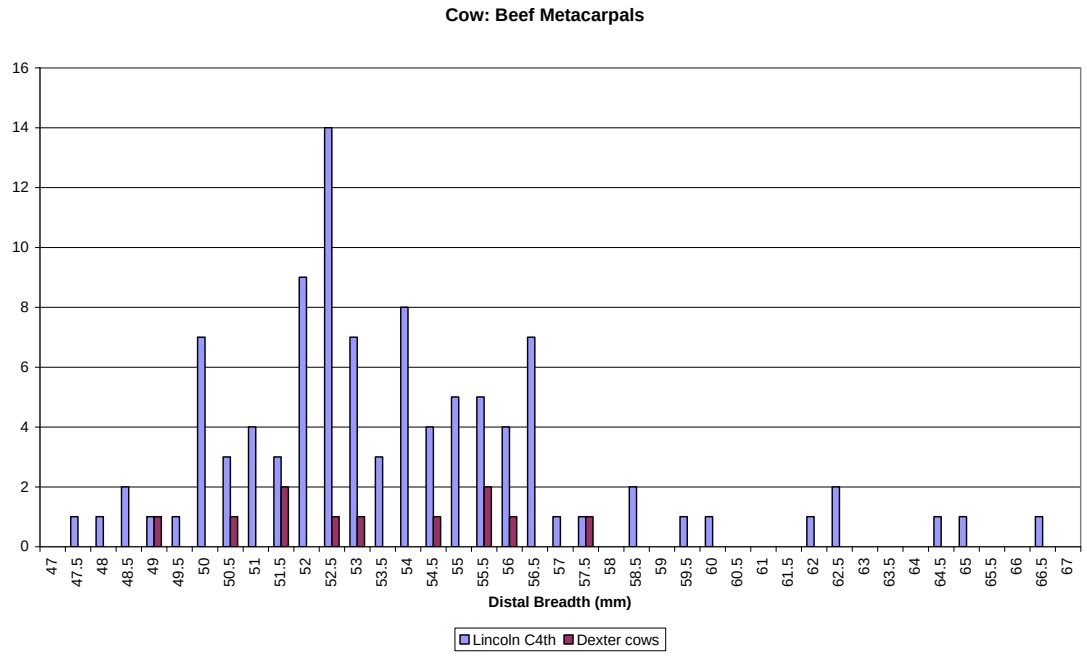


Figure 5: 9c C4th Lincoln and Dexters, astragali measurements

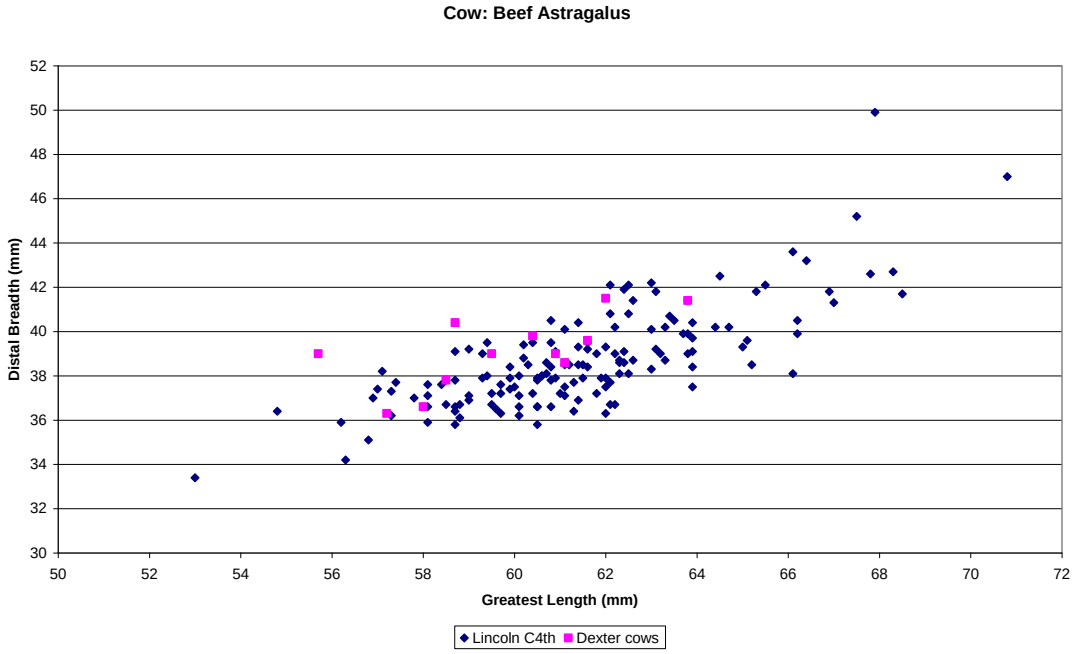


Figure 5: 10 Ripon and Dexters, Distal Breadth metacarpals

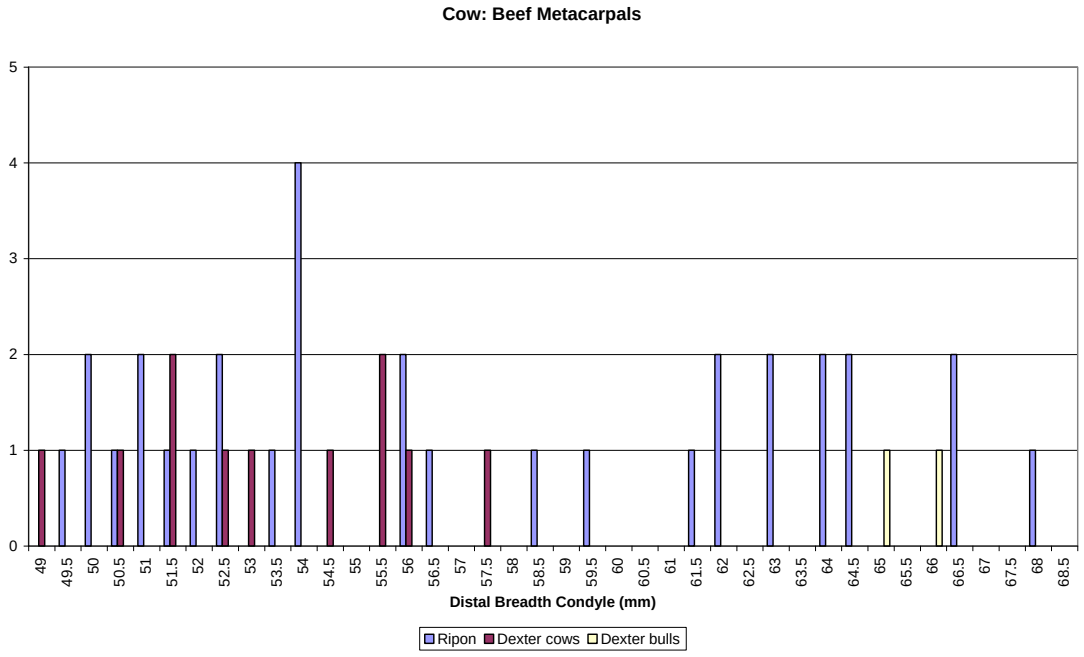


Figure 5: 11a Leicester and all Dexters, astragali measurements

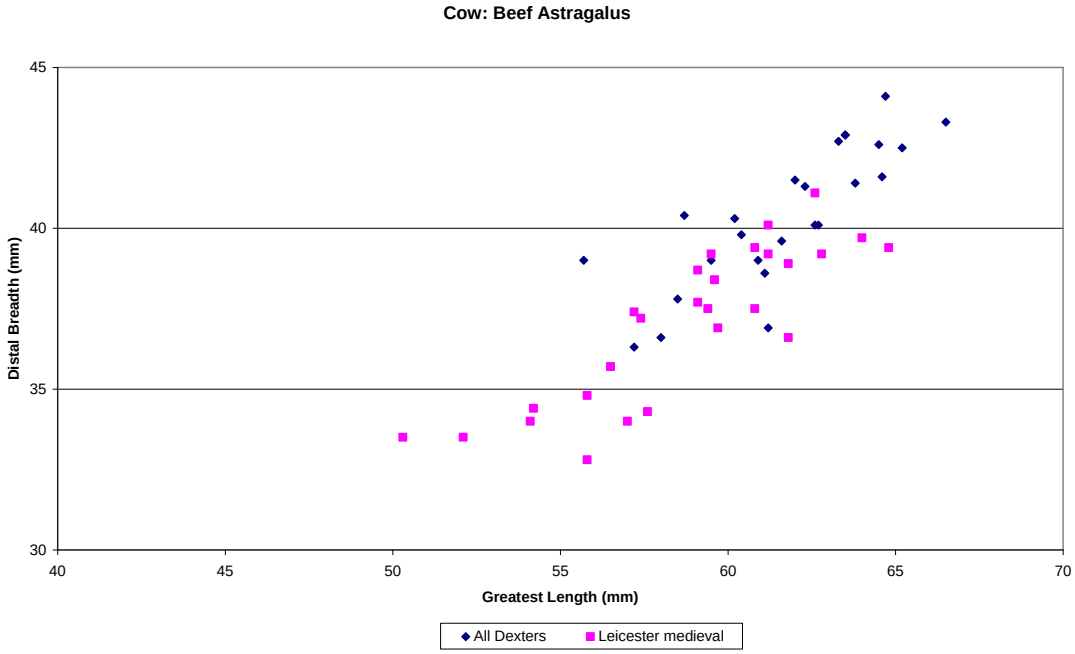


Figure 5: 11b Leicester and Dexter cows, astragali measurements

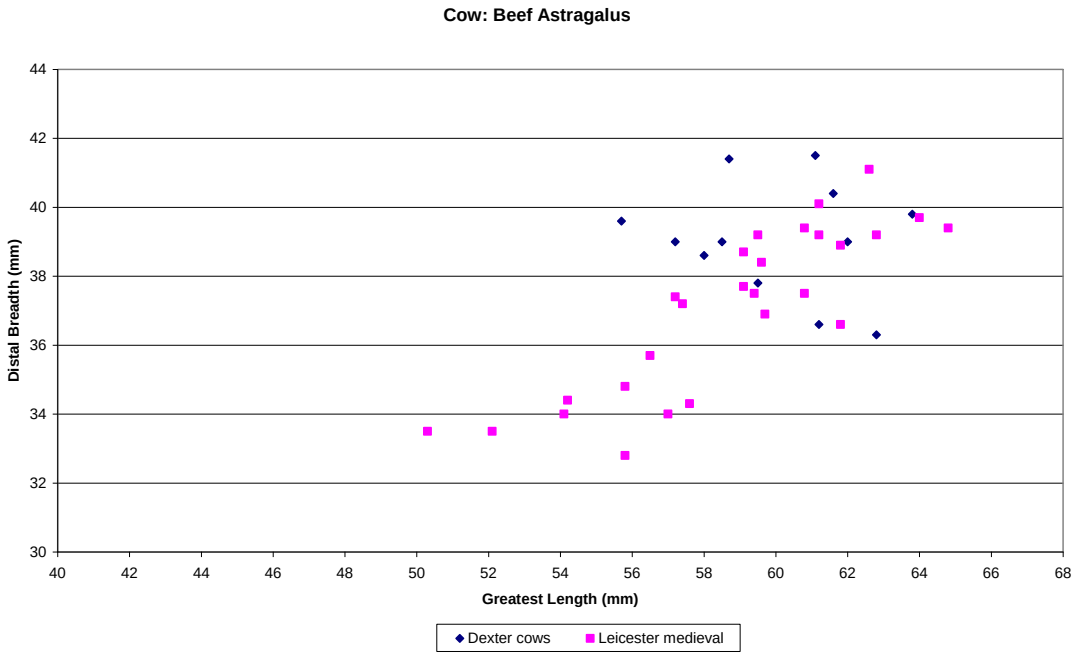


Figure 6: 1 Distal humerus trochlea measurements: Hadza, Dusty and all Dexter males

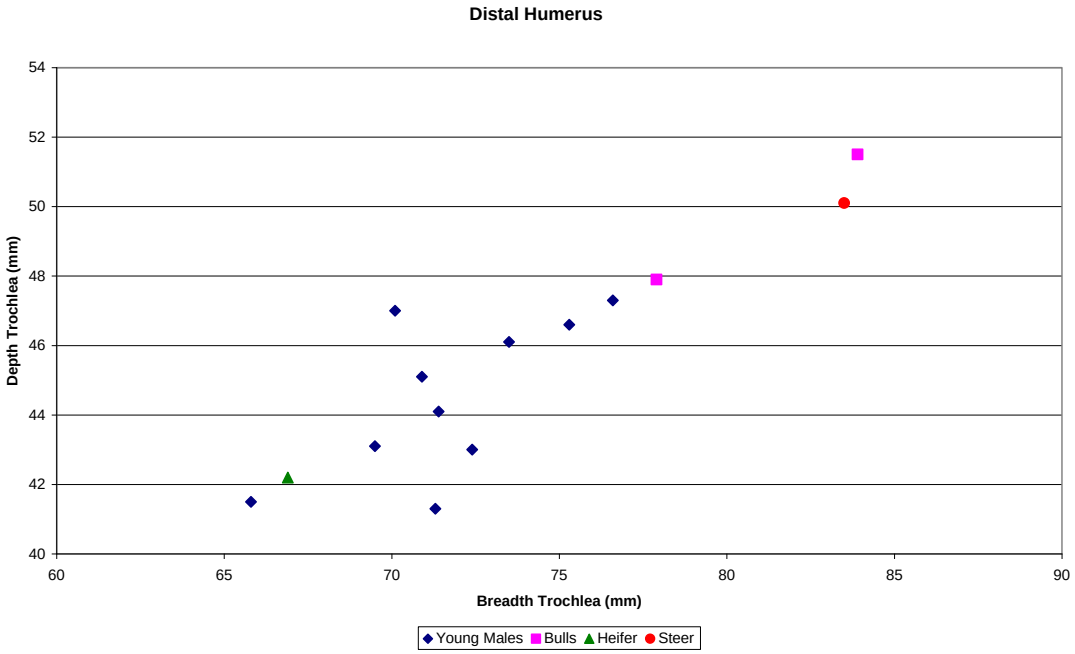


Figure 6: 2 Astragalus, comparison of GL and DB measurements: Hadza, Dusty, Dexter and Jersey X males

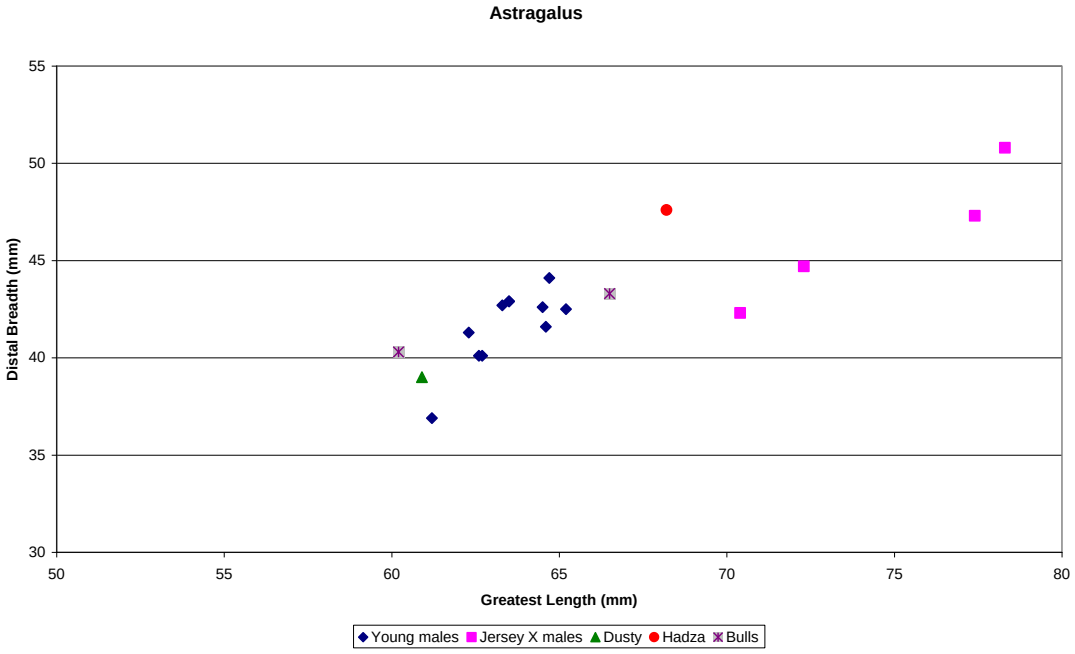


Figure 6: 3 Astragalus, comparison of GL and DB measurements: Hadza, all Dexter males and females

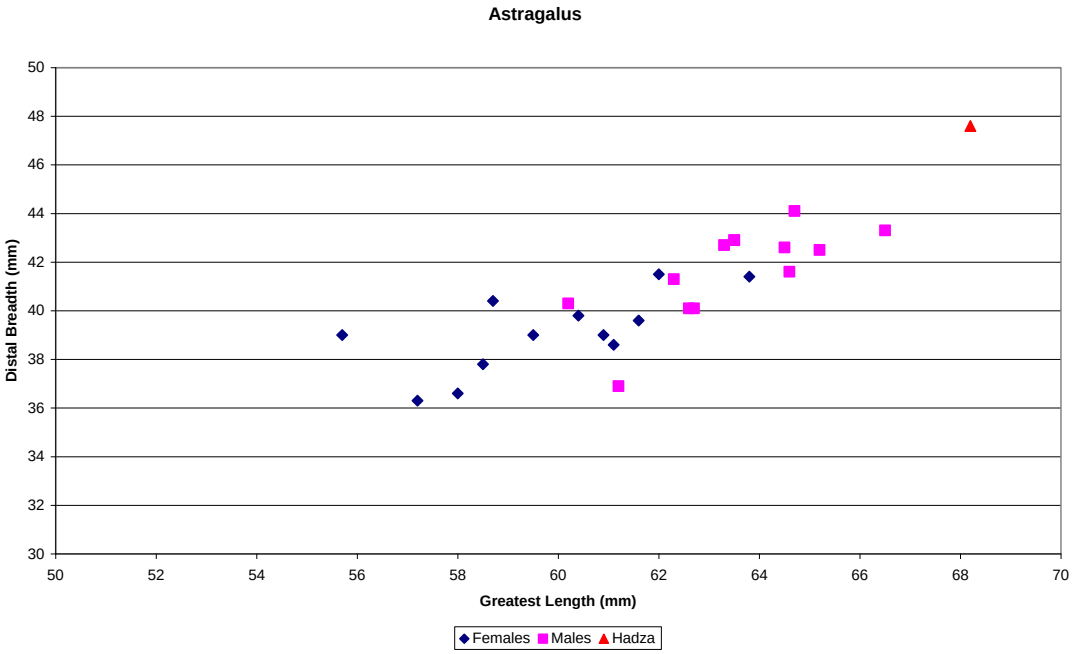


Figure 6: 4 Distal tibia DB and DD measurements: Hadza and adult Dexters

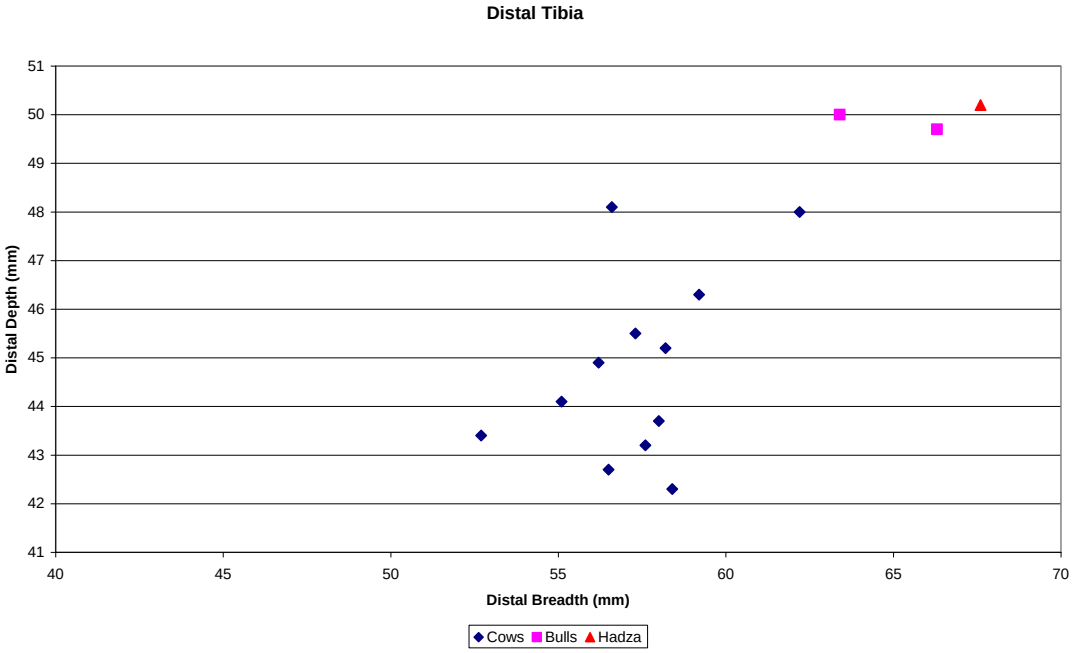


Figure 6: 5 Withers Heights estimated from metacarpal GL: Hadza and adult Dexters

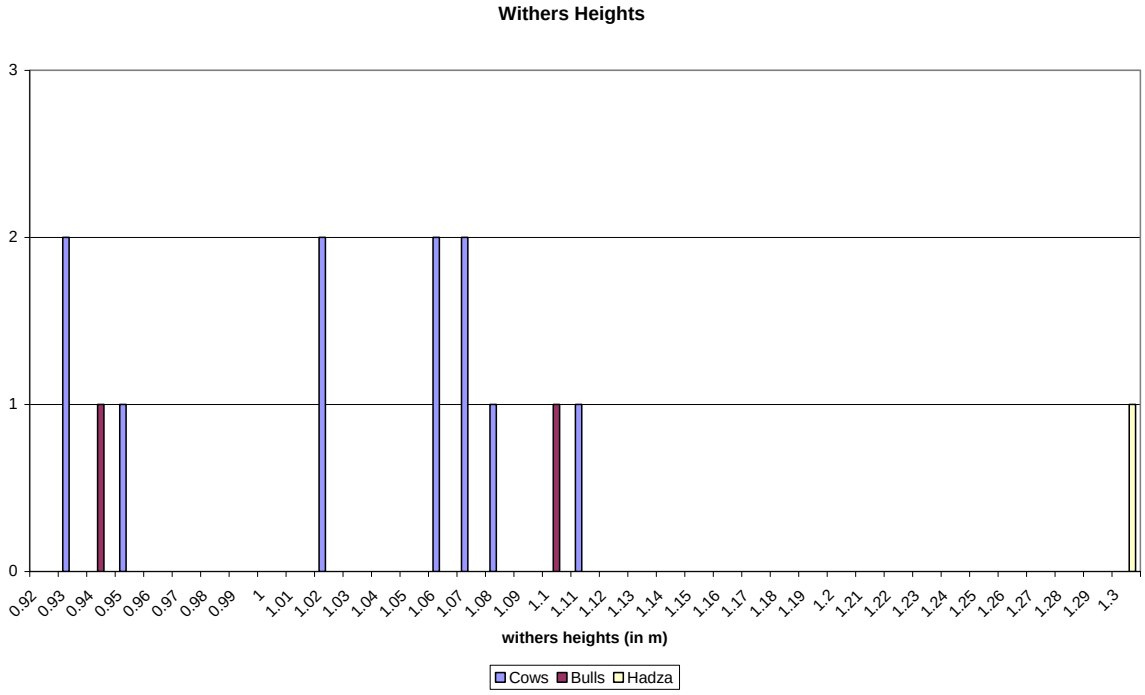


Figure 6: 6 Shapwick Burial Pit: MWS

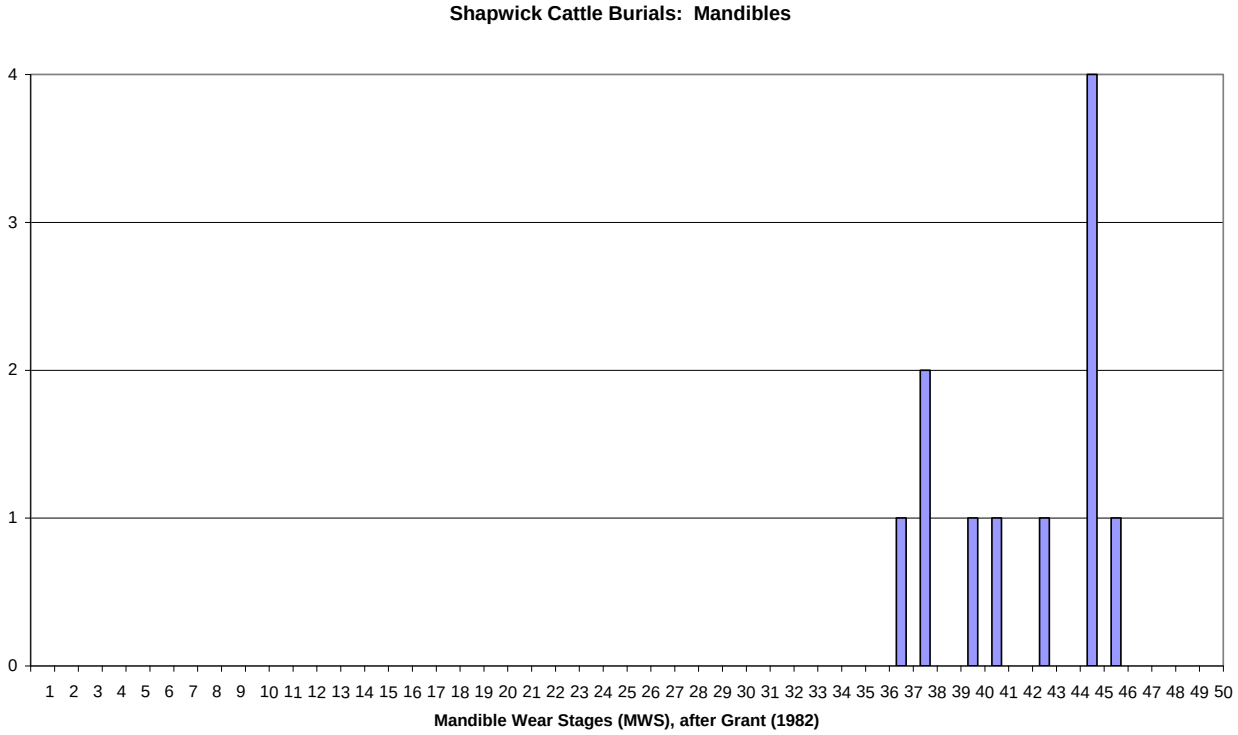


Figure 6: 7 Dorchester: withers heights estimated from metacarpal GL

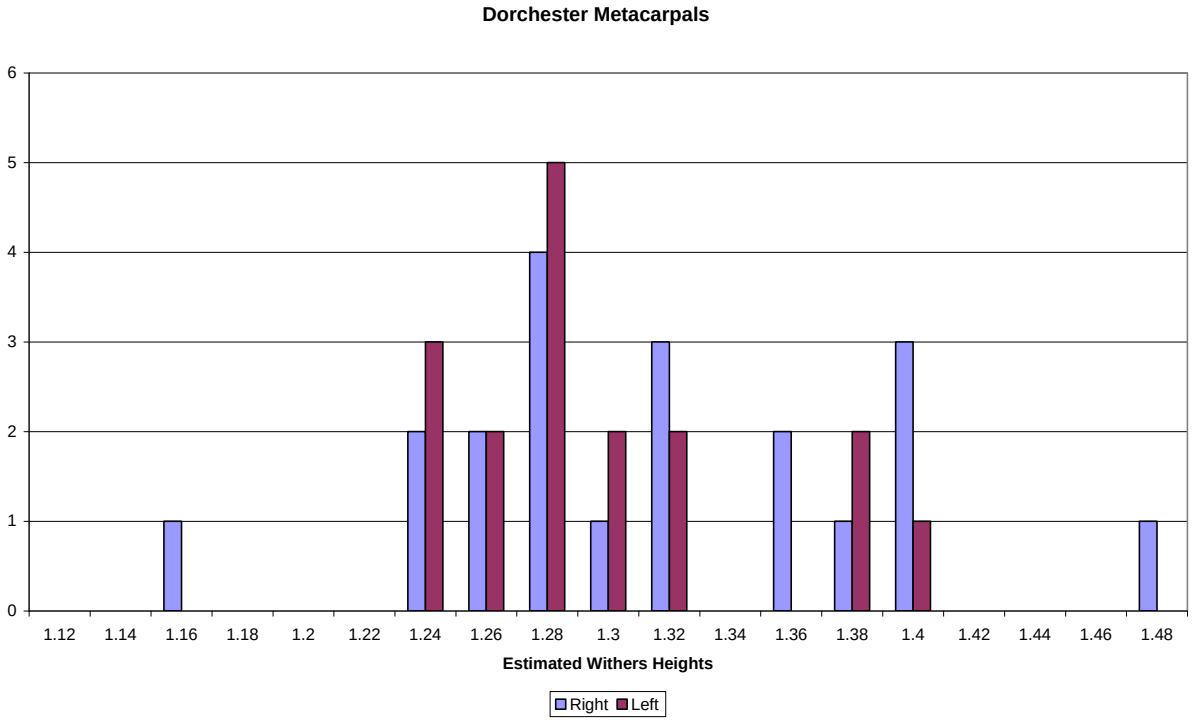


Figure 6: 8 Comparison of Dorchester and Alnwick estimated withers heights with Hadza, Brough St Giles and Comet

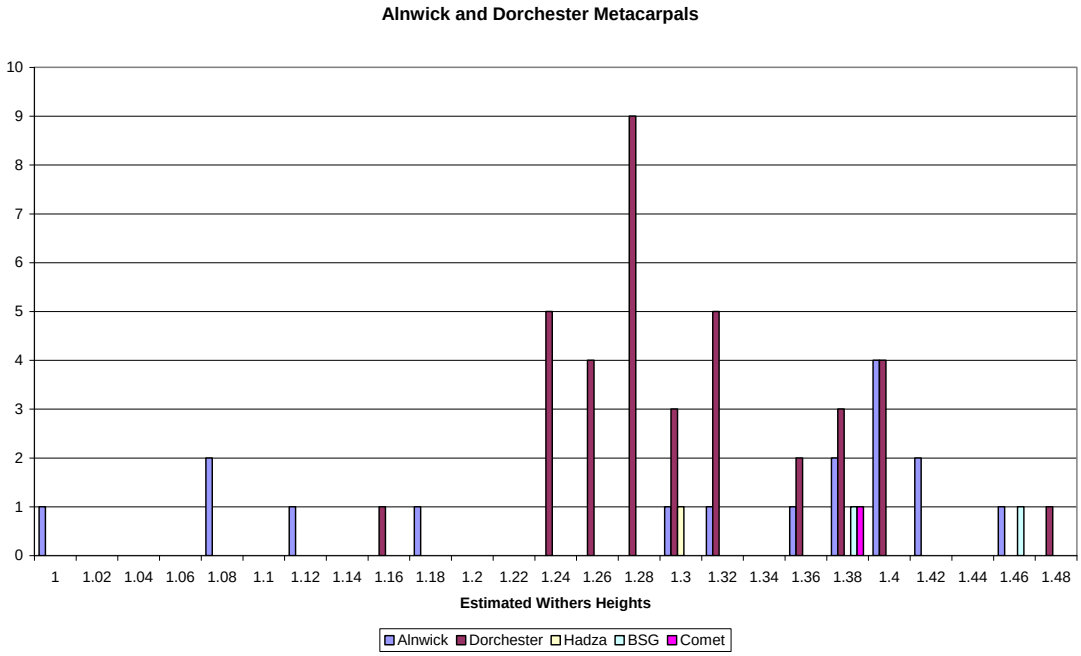


Figure 6: 9 Comparison of Dorchester and Masham proximal metacarpals PB with Hadza and Comet

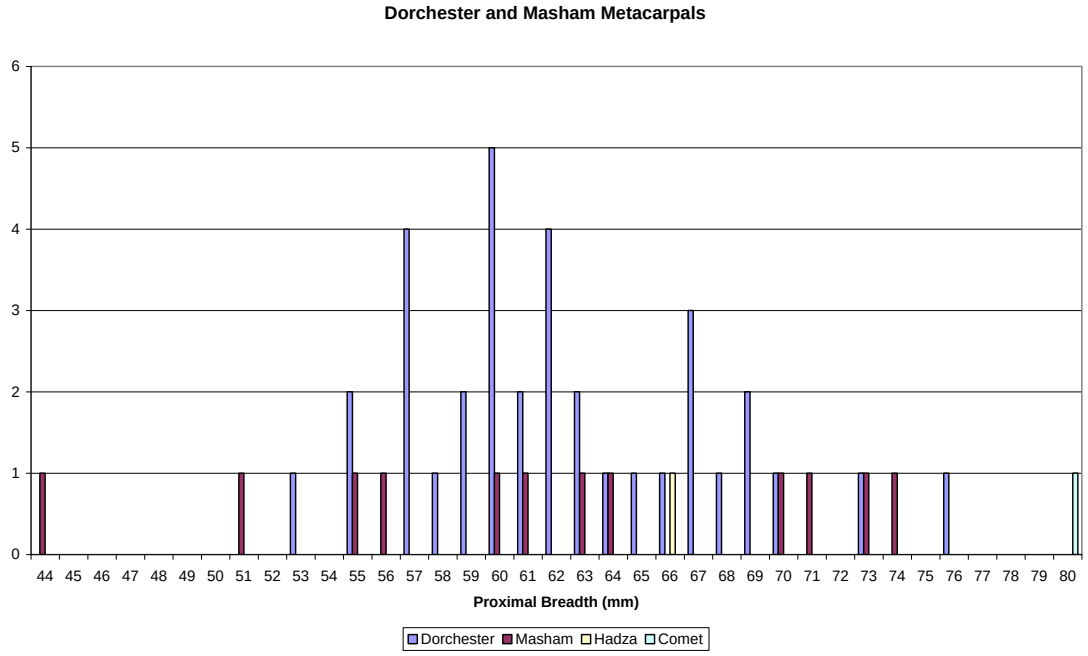


Figure 6: 10 Comparison of Dorchester and Masham distal metacarpals DB with Hadza and Comet

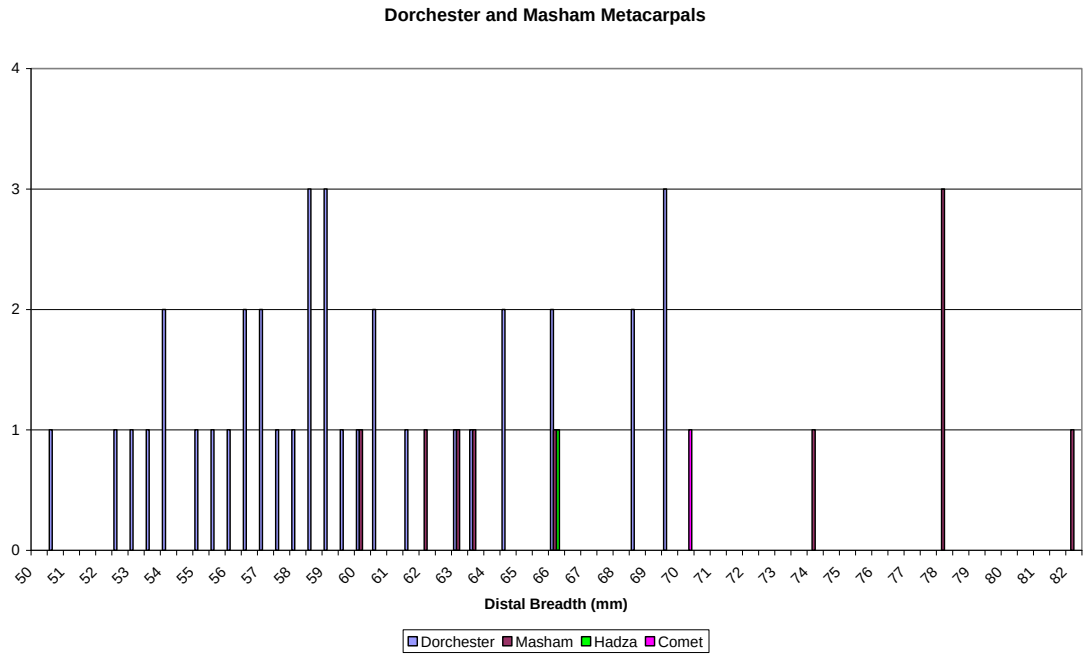


Figure 7: 1. Comparison of distal humerus breadth in Dexters with Hambledon Hill range

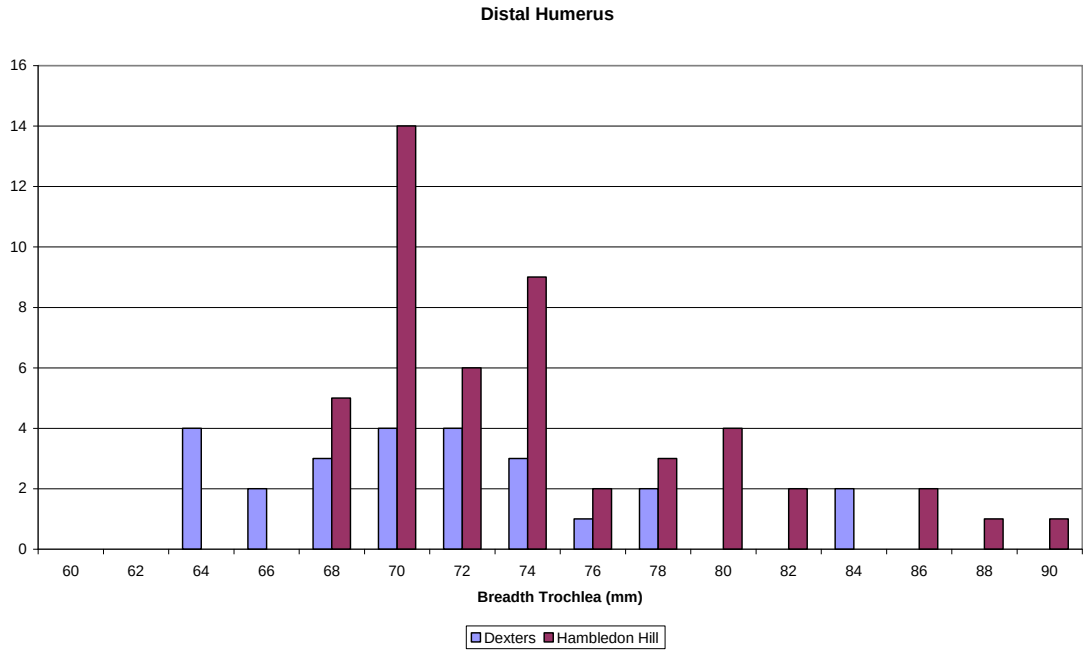


Figure 7: 2. Comparison of distal humerus breadth in male and female Dexters with Hambledon Hill range

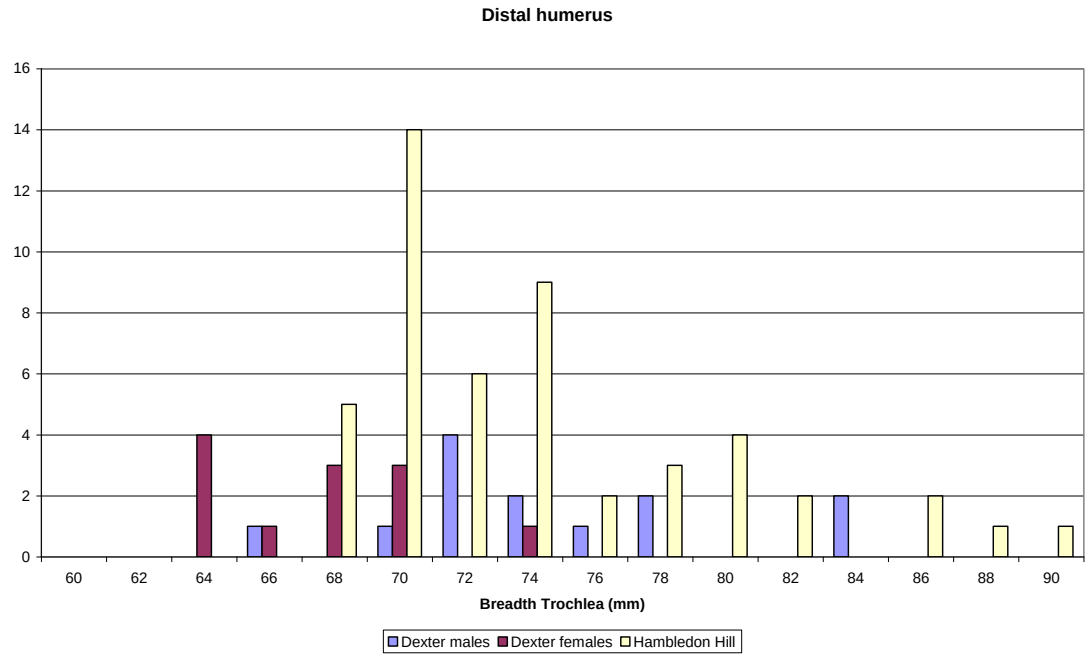


Figure 7: 3. Comparison of Hambledon Hill range with Dexters moved up to same size range

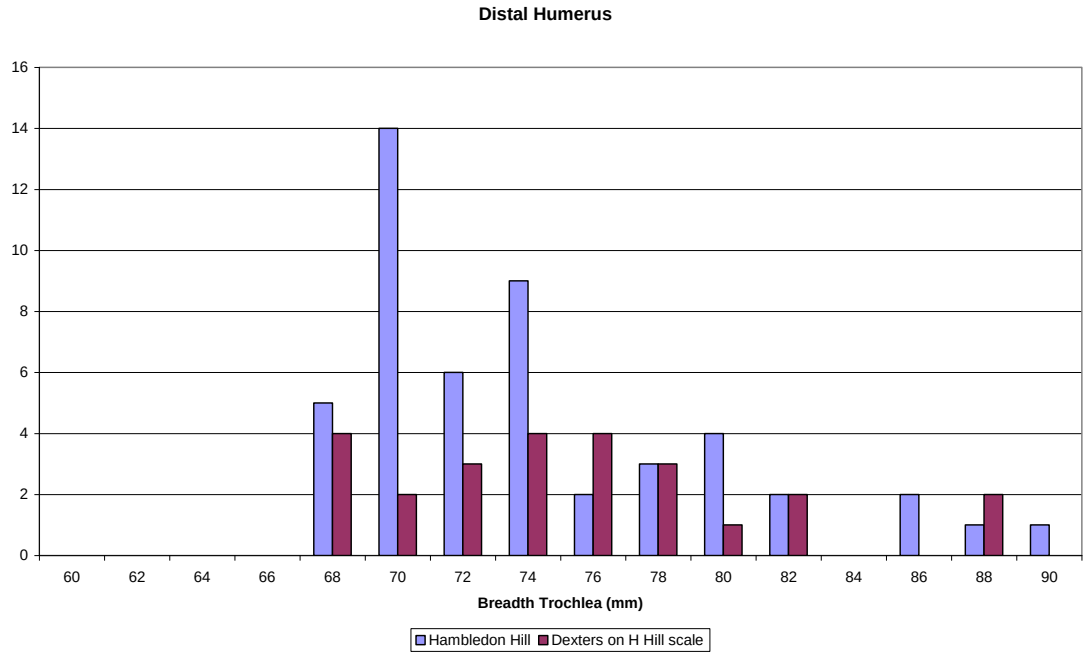


Figure 7: 4. Comparison of Hambledon Hill range with male and female Dexters moved up to same size range

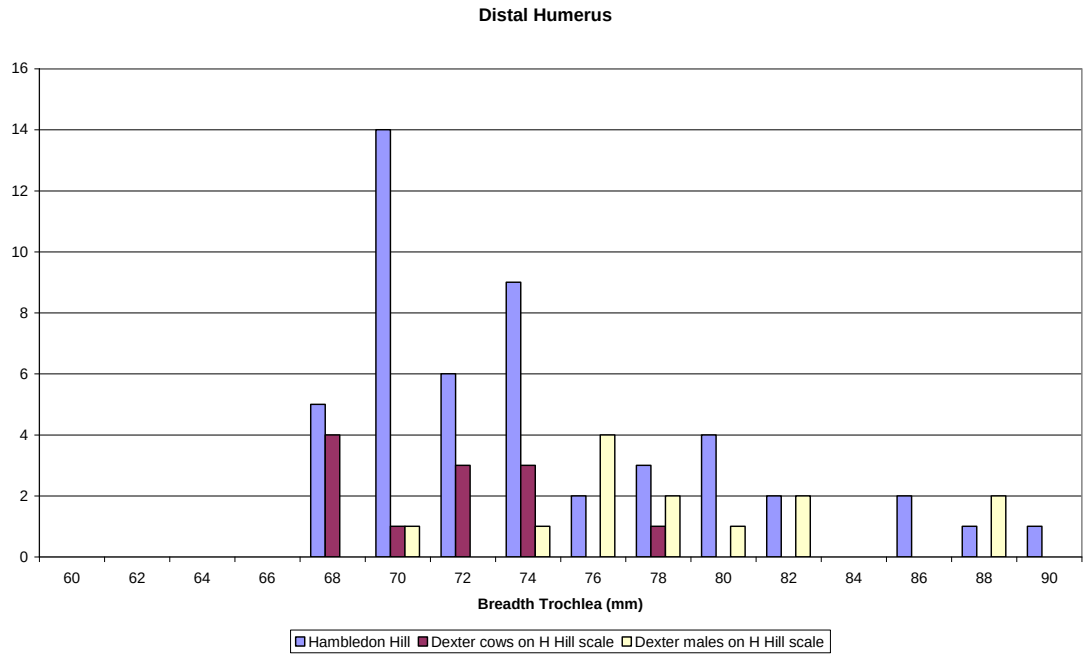


Figure 7: 5a. Scatterplot comparison of Hambledon Hill and Dexter humerus distal trochlea dimensions. The line approximates to Legge's (2008, 539) proposed separation between Neolithic domestic cattle and aurochs.

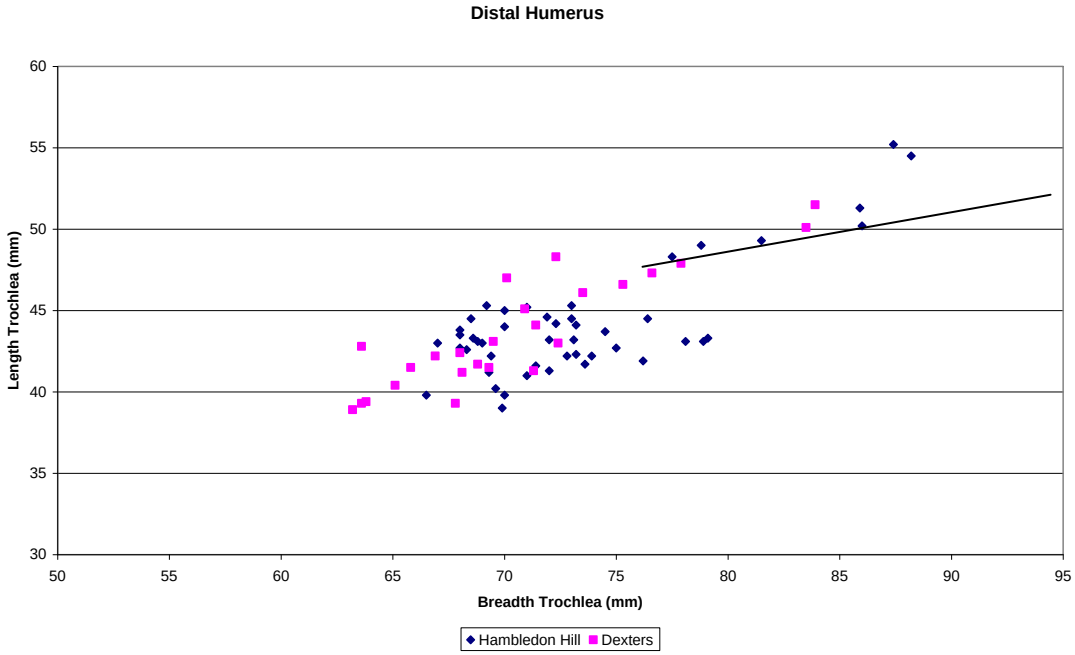


Figure 7: 5b Scatterplot comparison of Hambledon Hill and Dexter humerus distal trochlea dimensions with Hawick aurochs bull and Shorthorn bull Comet.

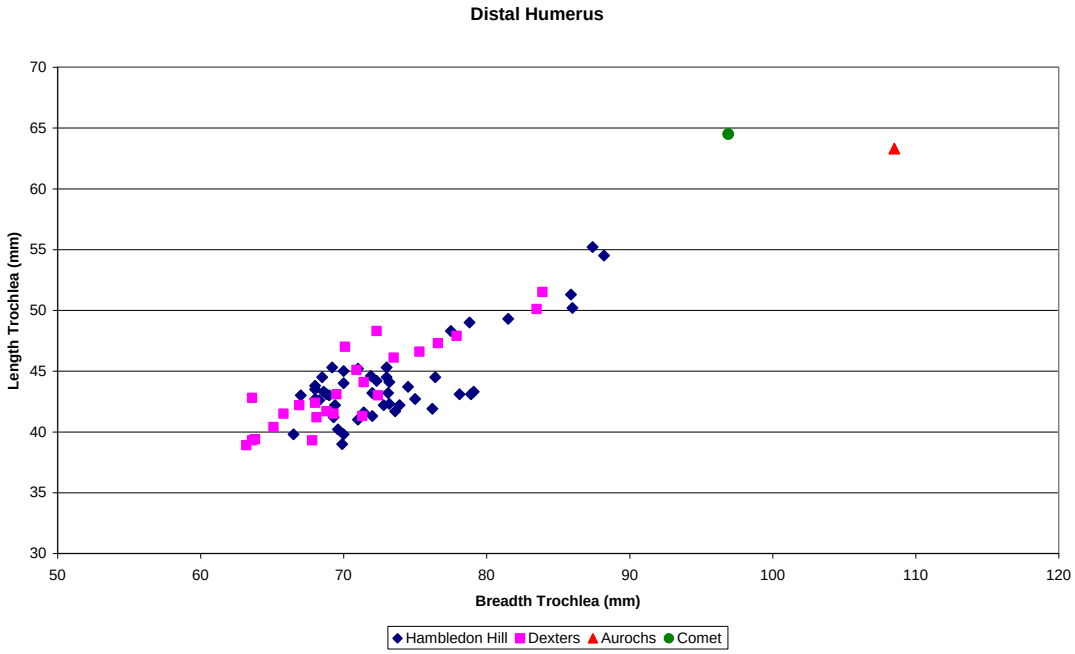


Figure 7: 5c Scatterplot comparison of Neolithic Rudston Wold and Hambledon Hill with Mesolithic aurochs. (from Rowley-Conwy and Owen 2011)

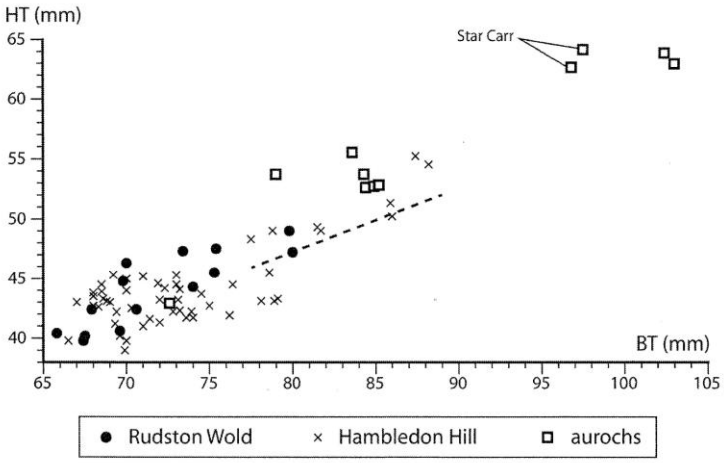
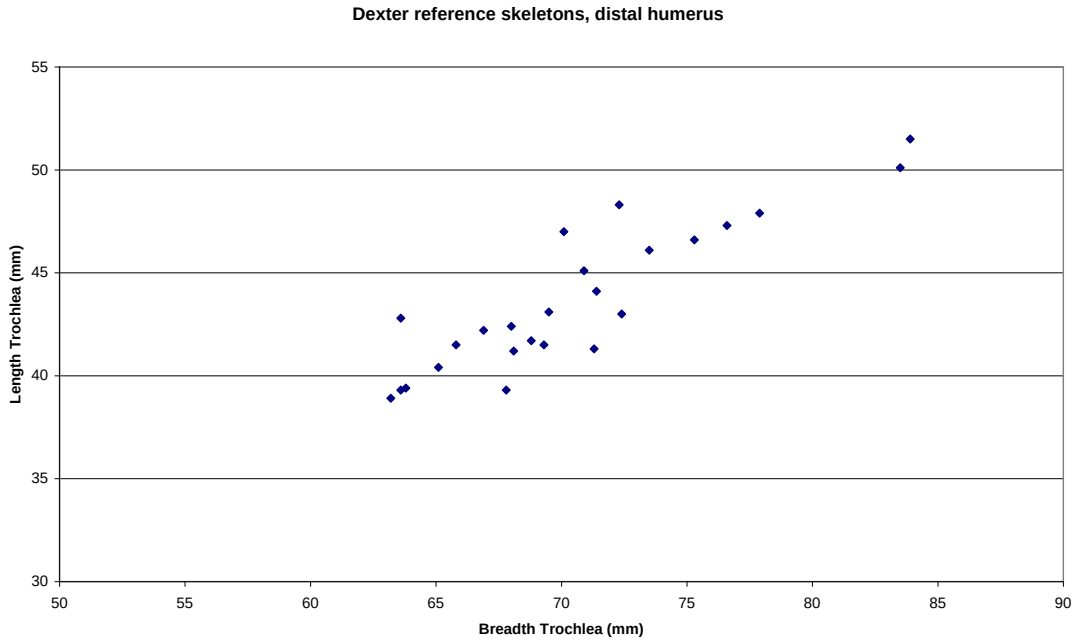


Figure 4

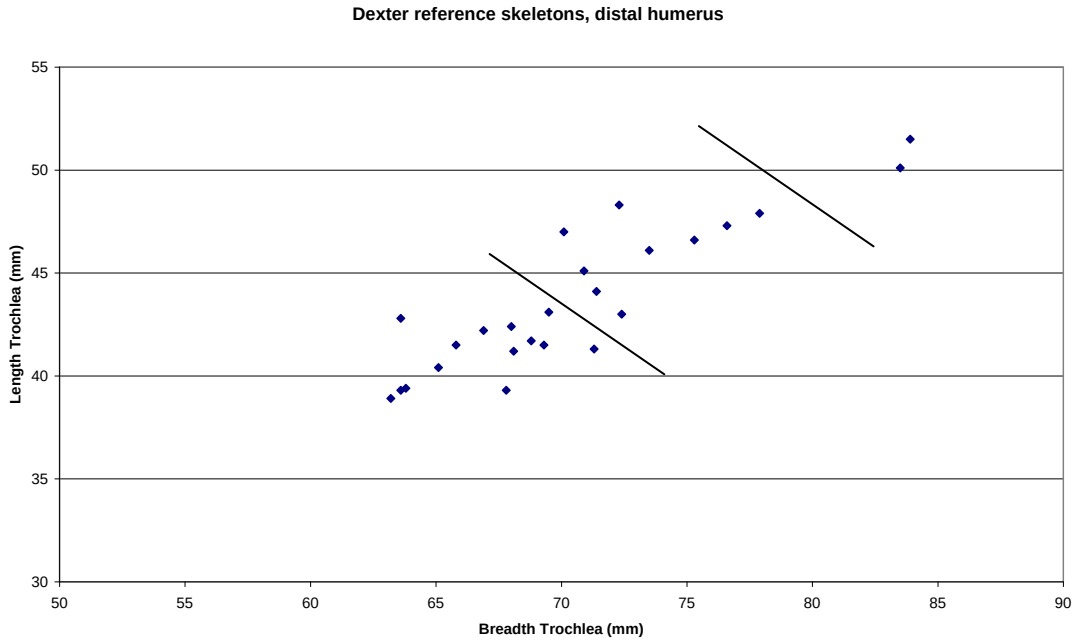
Dimensions of cattle distal humeri, plotting trochlea breadth (BT) against trochlea height (HT). BT is defined by von den Driesch (1976, fig. 32), HT by Legge and Rowley-Conwy (1988, 124). Dotted line marks division between female aurochs and male domestic cattle (Legge 2008, fig. 8.4). Hambledon Hill measurements from Legge (2008, table 8.27). Aurochs are from the Danish Mesolithic (unpublished research by Rowley-Conwy) except two from Star Carr (Legge and Rowley-Conwy 1988, table 8C).

Figure 7: 6. The whole sample of Dexter humerus distal trochlea measurements. Graph submitted to specialists with request to suggest division into male, female and castrate ranges.



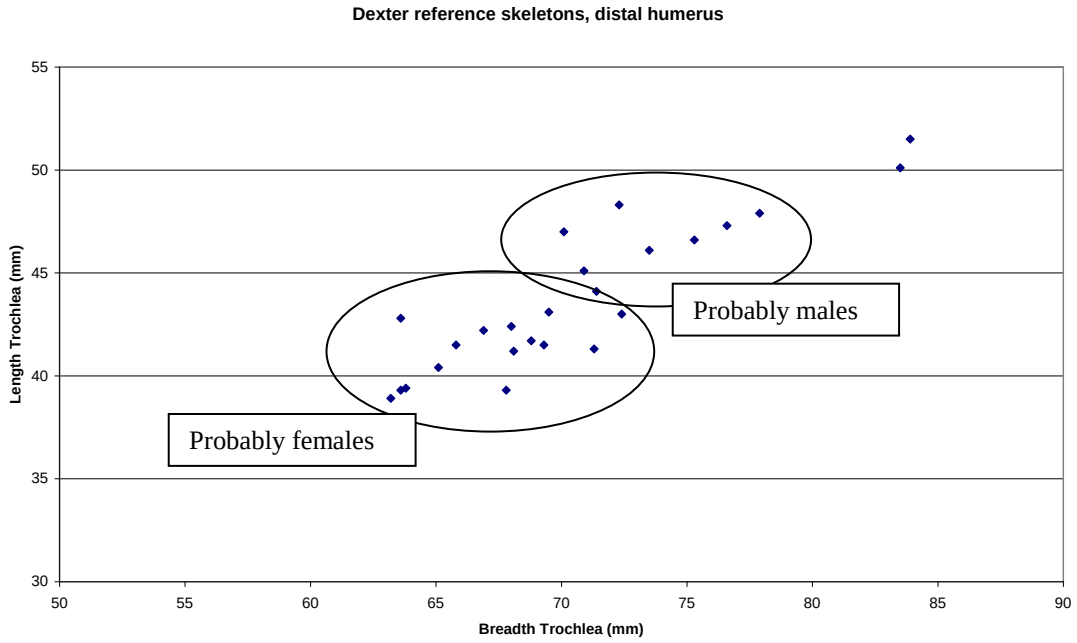
Figures 7: 7a-i Responses received to the request submitted with Figure 7: 6

Figure 7: 7a



This respondent considered that the group at the bottom of the range would be the cows. The two larger groups were assumed to be the males but the respondent was unsure which group would be the castrates and which the entire males.

Figure 7:7b



I would not normally try to base a sex-ratio estimate on such an early-fusing element, as there is likely to be appreciable growth and morphological change post-fusion. However, having been asked, the two ellipses enclose clusters that appear to show different 'best-fit' lines. The smaller ones tend to be medio-laterally narrow for their overall size. Those two clusters may be males and females if anything on this diagram separates them, and assuming both sexes to be present. As for intact/castrate males, the obvious thing would be to say the two big outliers are intact, and the remainder castrates. However, before jumping to that conclusion, I would enter a lot of caveats about timing of castration and nutritional plane.

Figure 7: 7c

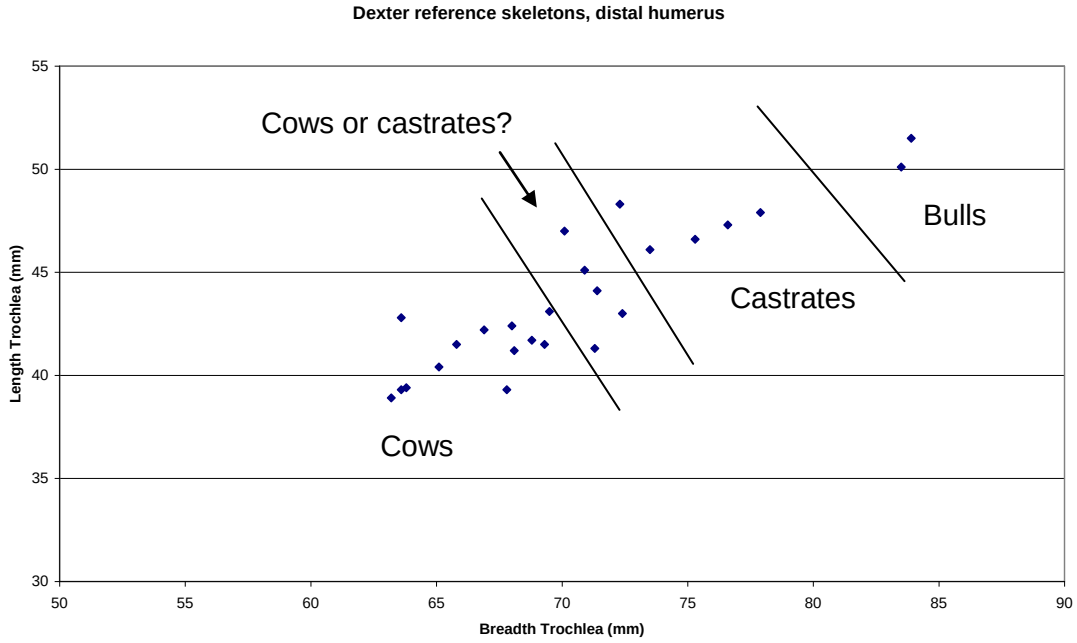
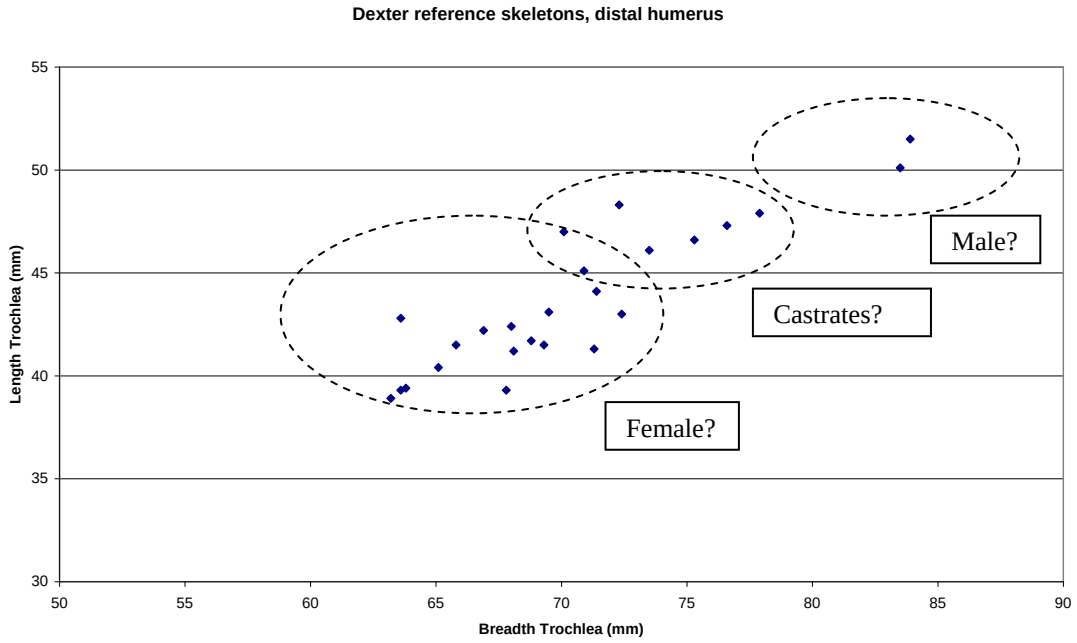
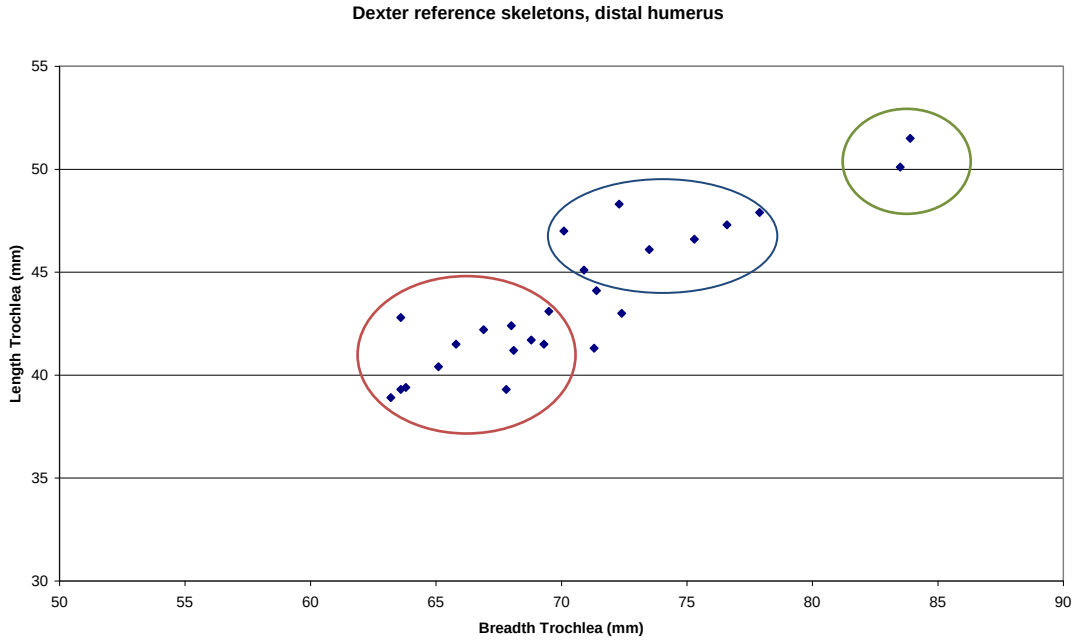


Figure 7: 7d



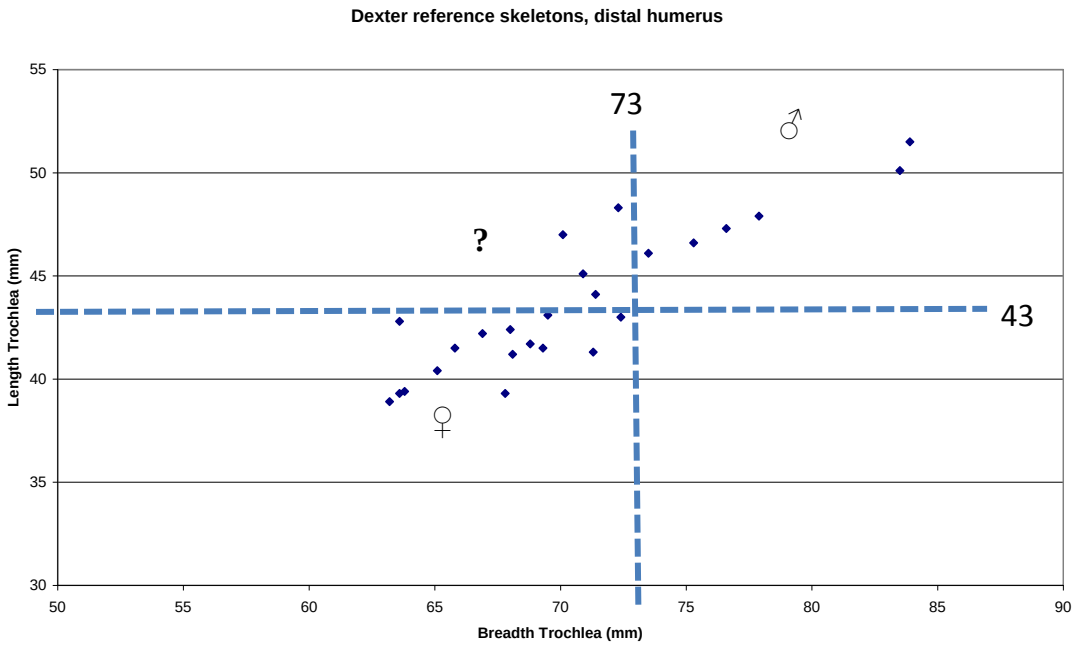
I've gone for circles rather than lines I hope that's okay. Above is my best guess. Although if it was a site I was working on I wouldn't include it in any report without lots of other info from other elements indicating a similar pattern.
After seeing the key, this respondent also commented that an unwitting assumption was made that all the cattle were mature, the presence of younger and older males was not considered.

Figure 7: 7e



I guess the traditional interpretation would be that the green circle would be the castrates, the blue the males and the red the females.

Figure 7: 7f



This respondent used the dimensions of a known sex reference specimen to suggest the boundary between males and females.

Figure 7: 7g

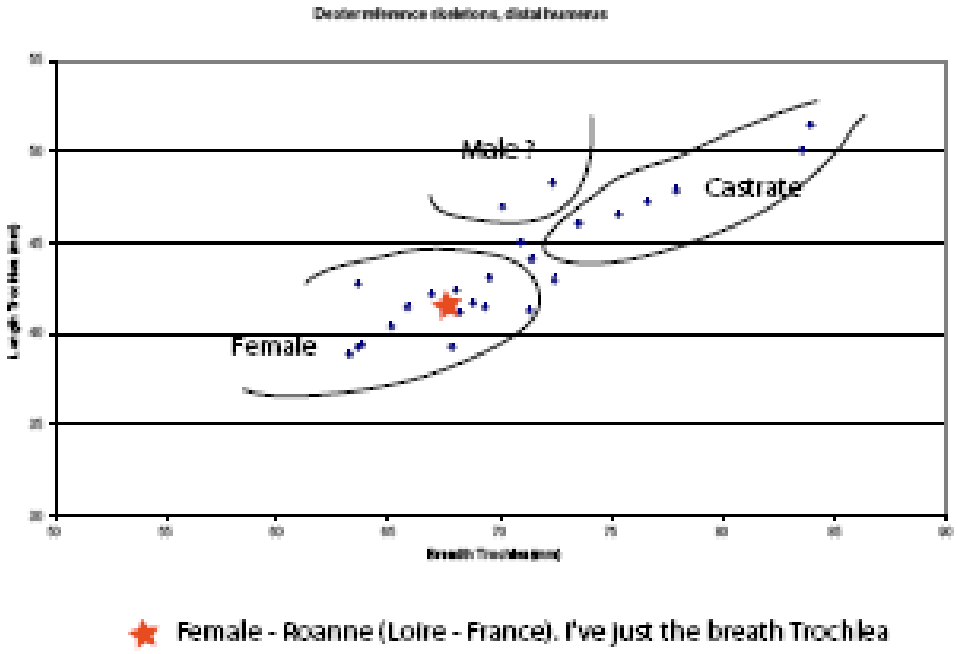
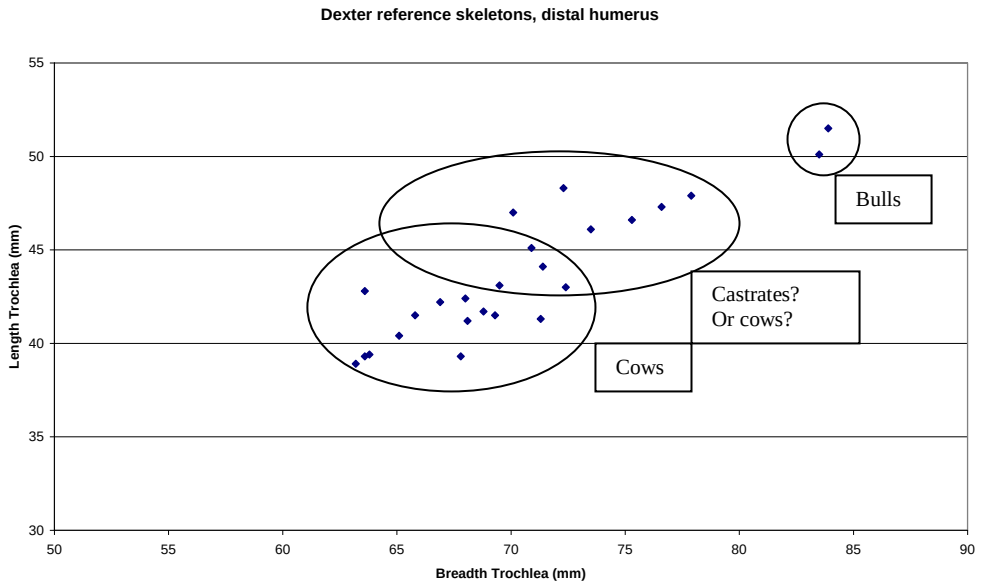
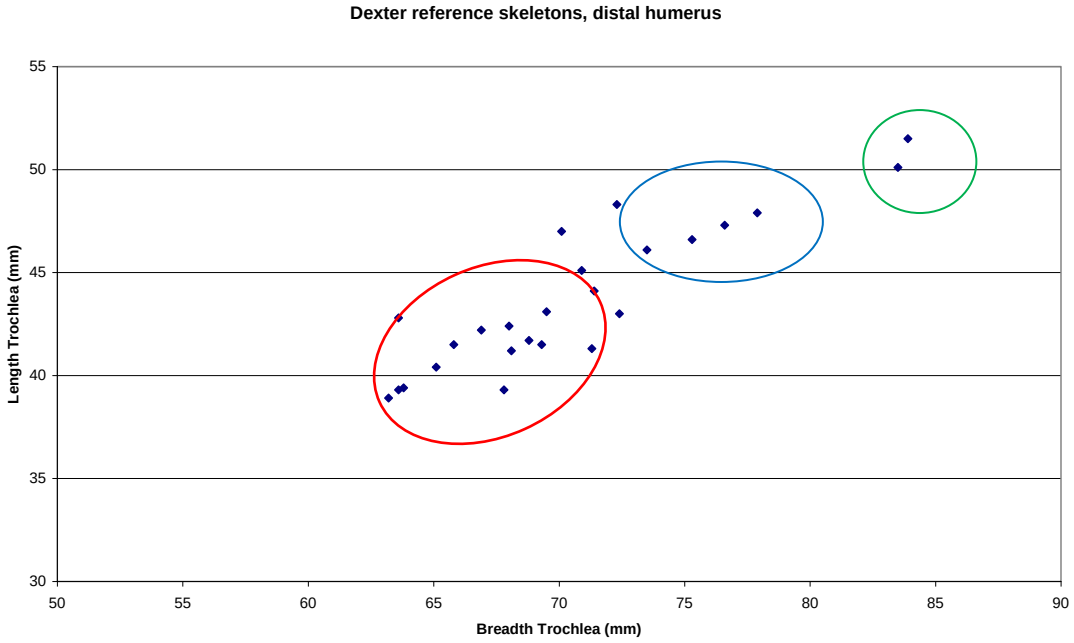


Figure 7: 7h



This is really guesswork, without known sex reference measurements to compare one cannot really sex this big group.

Figure 7: 7i



Not an analysis I would normally consider, and certainly not without a reference collection - but this is a reference collection! Purely on gut feeling I would suggest the green circle as castrates, the blue circle as entire males and the red circle as females.

Figure 7: 7j

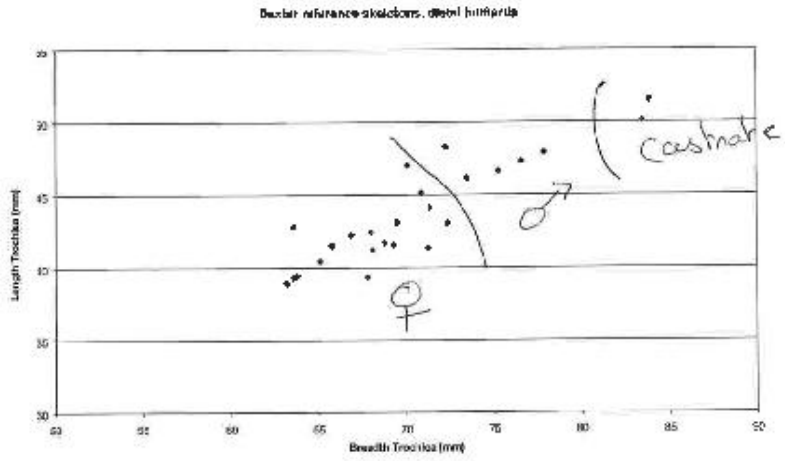


Figure 7: 8a. Key to sex/age distributions in Figure 7: 6

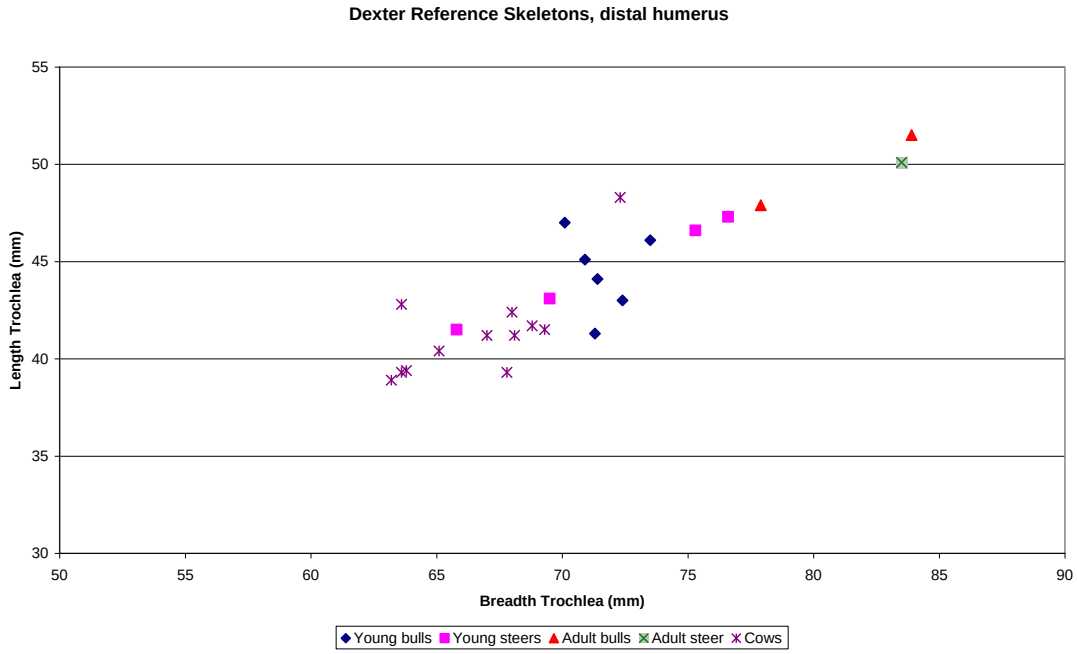


Figure 7: 8b. Key to Short (S) and Non-Short (NS) male and female Dexters in Figure 7: 6

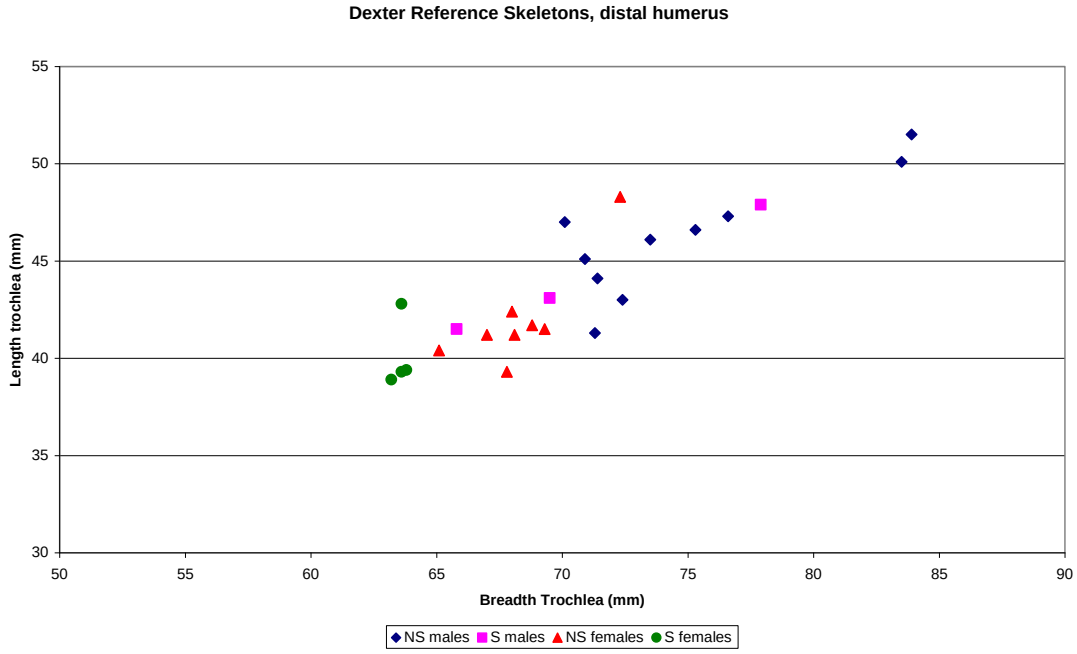


Figure 7: 9. Comparsion of Dexter distal humerus measurements with Bronze Age Grimes Graves

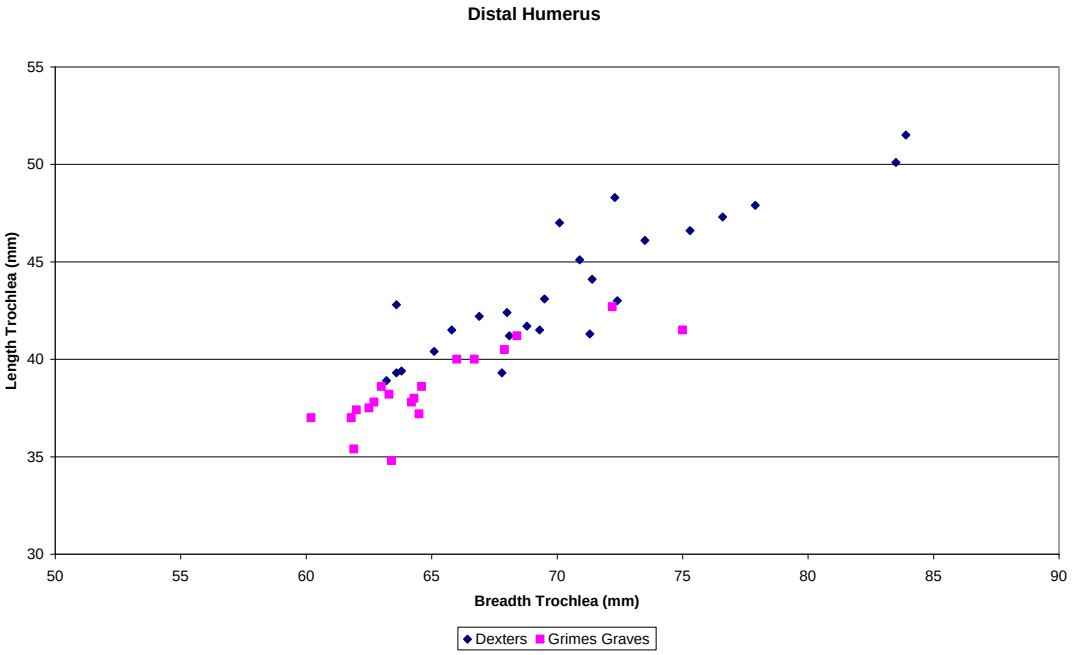


Plate 1:1

Detail of *Farm Girl at her Toilet* by Lepoittevin. French 19th century.

(by kind permission of the Bowes Museum)

Plate 2:1. Dexter bull Aiskew Juglans Nigra left, and cow Chalena 6th of Zelston right in life, showing the lack of pronounced sexual dimorphism in height in the non-short Dexter. Skeletons of both animals are in the reference collection.

Plate 2: 2a. Countrywoman confronting bull, by Bewick c. 1790

Plate 2: 2b. Man running from bull, by Bewick c. 1790

Plates 2: 3a.Yoked bull (world wide web image)

Plate 2: 3b Yoked bull (world wide web image)

Plates 2: 3a-b show two examples of draught bulls being worked in single yokes in the Far East today. The black bull, 2: 3a, does not seem to be humped. The red bull, 2: 3b, appears humped but in fact the hump is partly caused by the pressure of the yoke mounding up the soft tissue of the neck. This both cushions and supports the yoke, and increases the load-bearing surface area between the yoke and the bull.

Plate 2: 4. Bull fight in Thailand (postcard)

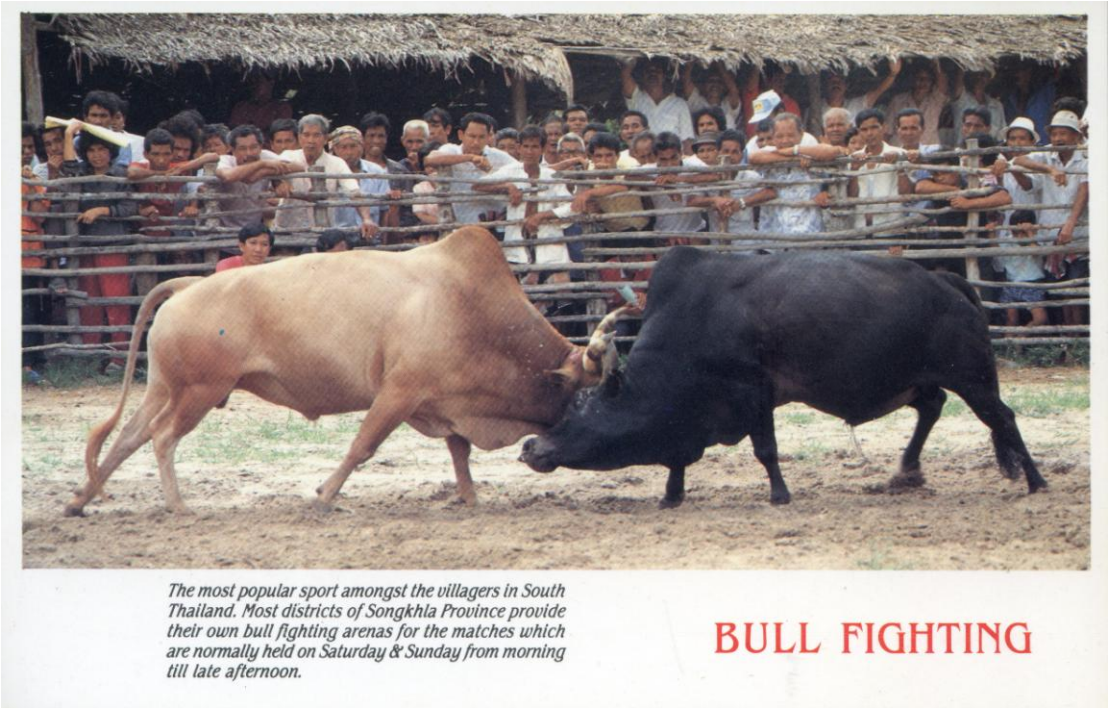


Plate 2: 5. Reproduction of Roman oil lamp showing acrobat pole vaulting over bull

Plate 2: 6. Aiskew Juglans Nigra competing at the East of England Show, 1993

Plate 2: 7. Alcalde, aged 16, premier sire of bulls for the Spanish bullring (International Herald Tribune online March 2008)

Plate 2: 8. Roman amphitheatre at Arles with bull fight in progress (world wide web image)

Plate 2: 9. Limousin cattle with “Celtic Shorthorn” shaped horns (Susanna Heath)

Plate 2: 10. Dalmuir Cyclone, left, and Aiskew Juglans Nigra, right, in harmony together

Plate 2:11a
Thomas's favourite head-rubbing site

Plate 2:11b
One of Juglans Nigra's pawing grounds, still visible some ten years after his death

Plate 2:11c
Shed repaired after use by Orlando for head-rubbing

Plate 2:11d
Lawrence's head and neck rubbing activity area

Plate 2: 12a
Bull Zanfara Orlando showing robust neck

Plate 2: 12b
Cow Zanfara Thomasina showing gracile neck

Plate 2:13a Sacrum of Juglans Nigra fused to iliac blades of pelvis (Jeff Veitch)

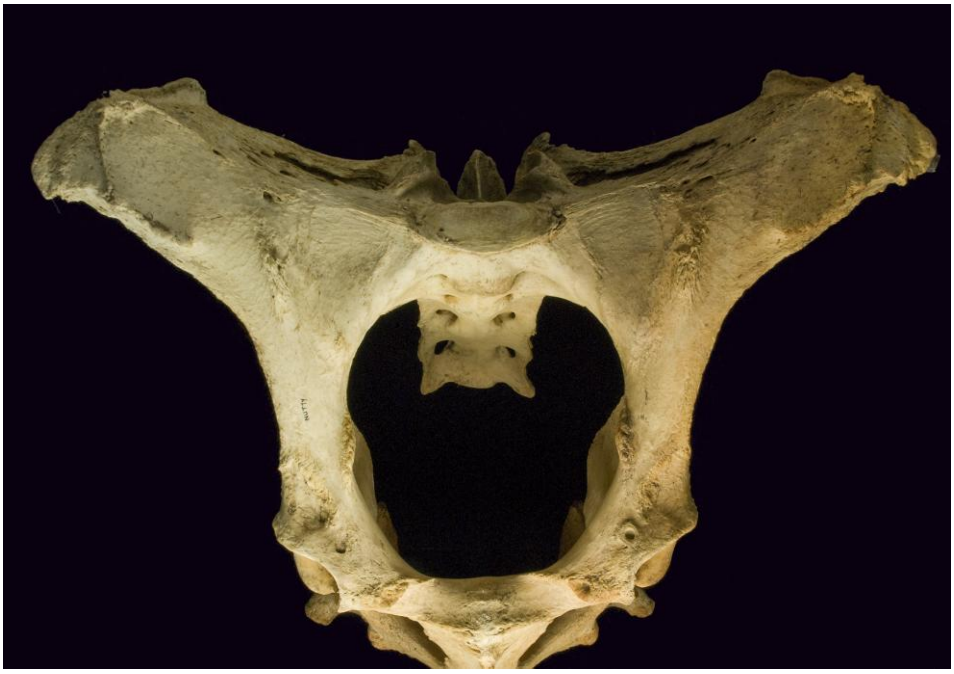
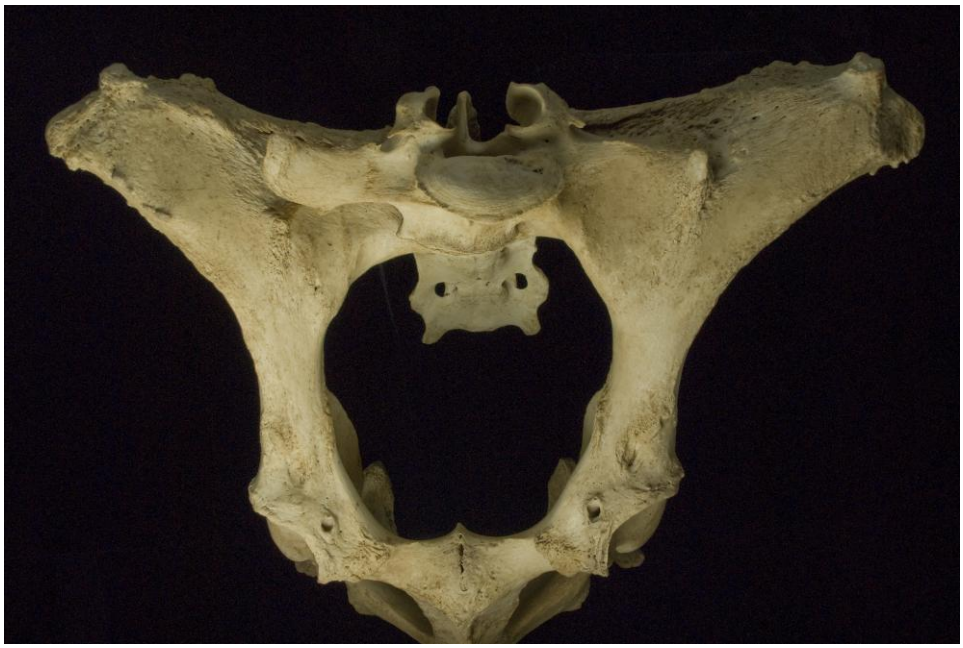
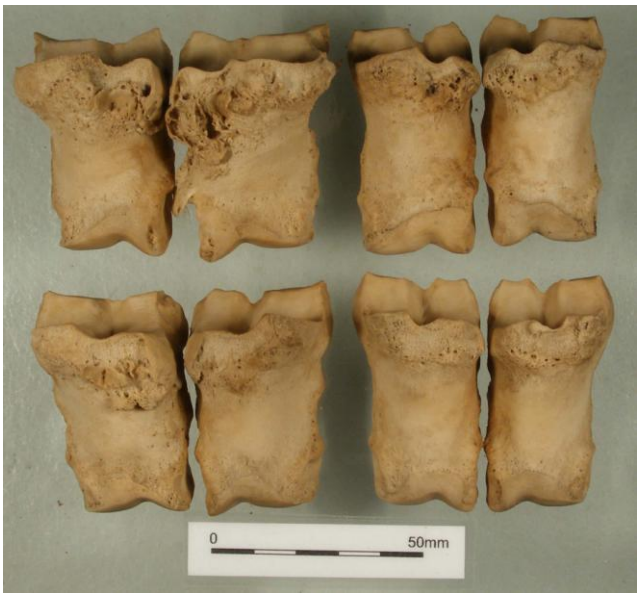


Plate 2:13b Sacrum of Cyclone fused to iliac blades of pelvis (Jeff Veitch)

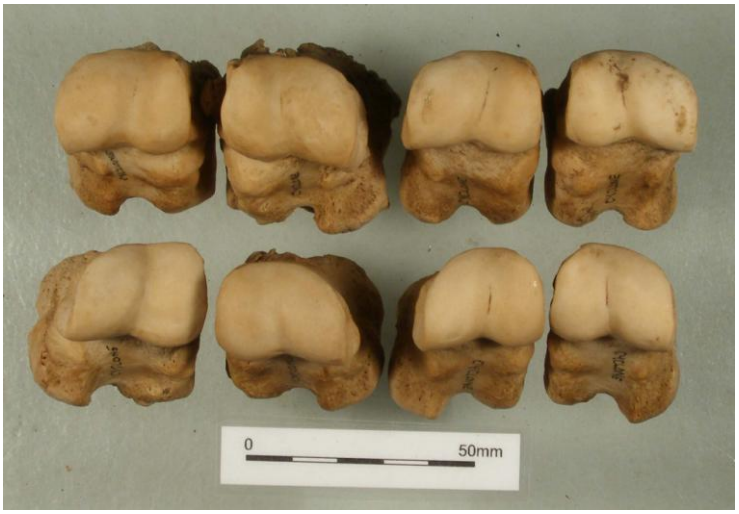


Plates 2:14a-c First phalanges of Cyclone showing the range of exostosis development

2: 14a anterior aspect



2: 14b distal articulation



2: 14c proximal articulation

Plates 2:15a-b. Second phalanges of Cyclone

Plate 2: 15a anterior aspect

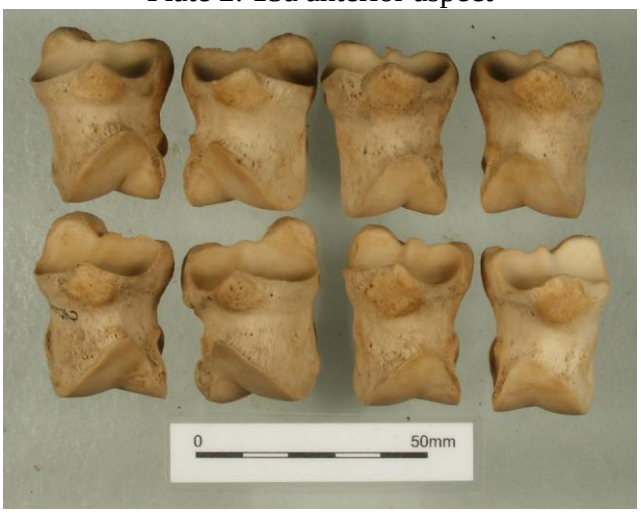


Plate 2: 15b distal articulation

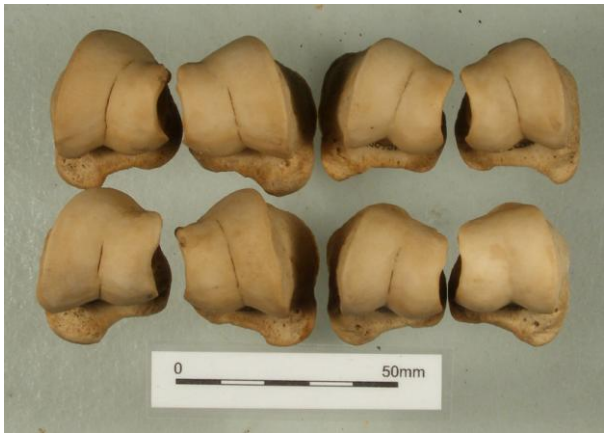


Plate 2:15c. Third phalanges of Cyclone

Plate 2:16a
Detail of surface modelling on humeri of Juglans Nigra, left, and aurochs, right.

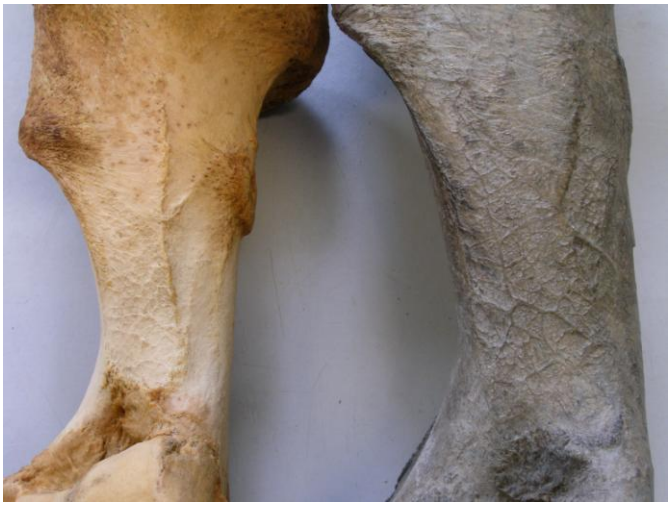


Plate 2:16b
Scapulae, L-R aurochs, Juglans Nigra, Cyclone and Chillingham, showing the gracile build of the Chillingham

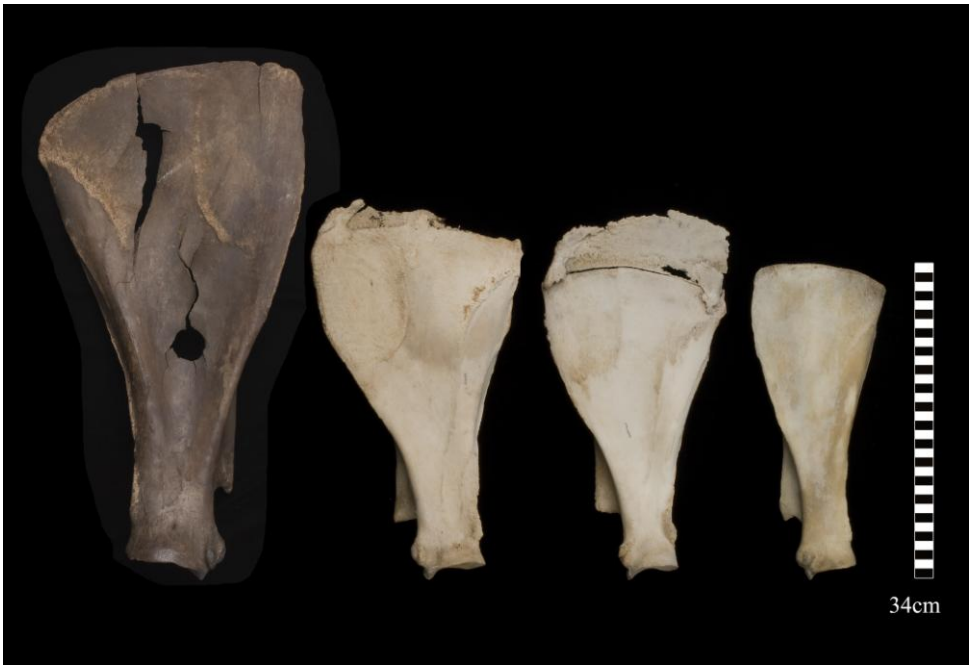


Plate 2:16c Humeri, L-R aurochs, Juglans Nigra, Chillingham, Cyclone

Plate 2:17
Atlas vertebrae, top Chillingham, centre Cyclone, bottom Juglans Nigra

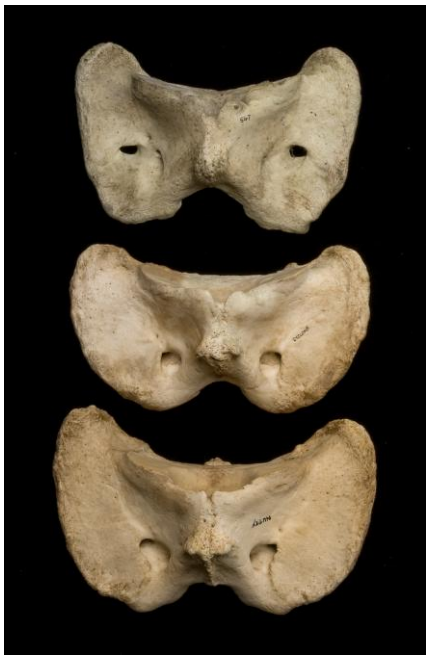


Plate 2:18
Radius and ulna, L-R Cyclone, Juglans Nigra, Chillingham

Plate 2:19
Metacarpals, L-R Cyclone, Juglans Nigra, Chillingham

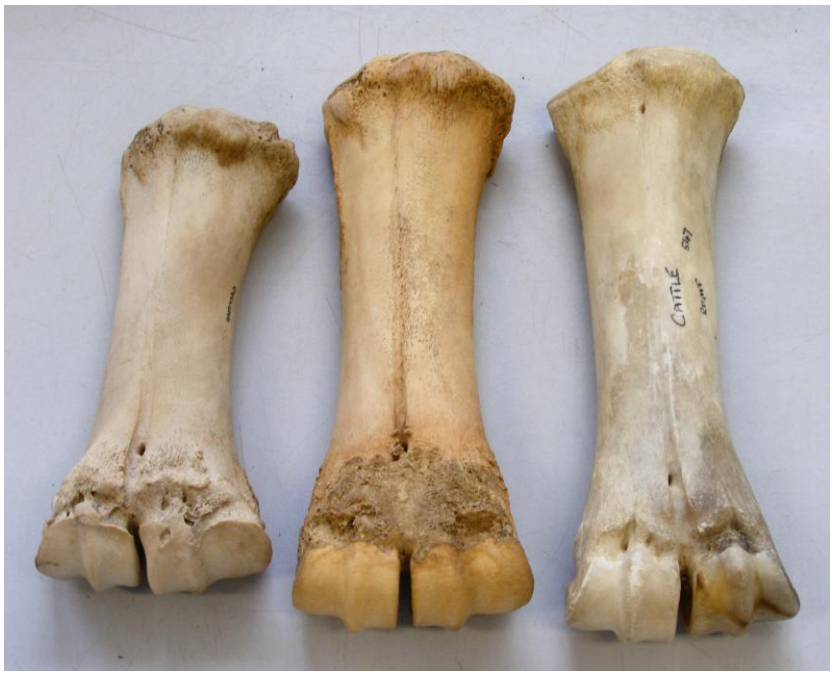


Plate 2: 20. Comet in 1811, aged 7, a year after the Colling's dispersal sale. Detail of painting by Thomas Weaver.

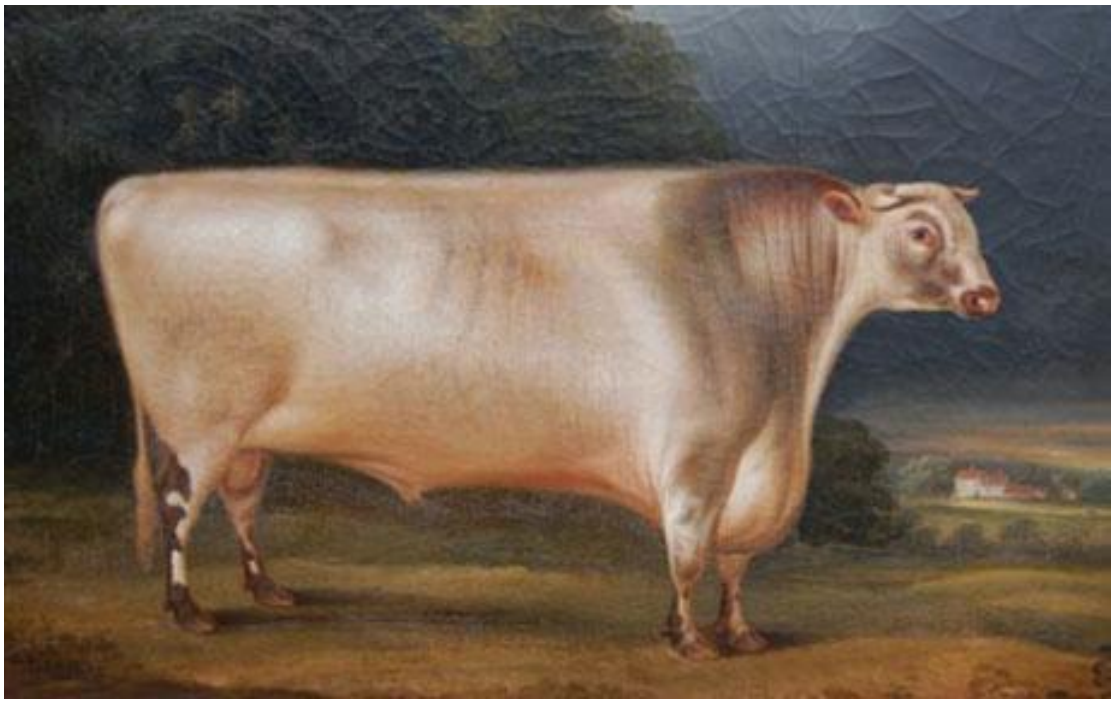


Plate 2: 21.
Malocclusion on right hand mandibular molar 3 of Comet, indicative of a "hooked" occluding maxillary molar 3.

Plates 2: 22a-c
Left scapula of Comet showing ossification round the joint capsule in response to subluxation

2: 22a: medial aspect

2: 22b: lateral aspect

2: 22c: Detail of eburnation in the glenoid fossa

2: 22d: detail of ossification round the margins of the joint capsule

Plate 2: 23. Comet right humerus, proximal end showing extension and fusion of the lateral and medial tuberosities

Plate 2: 24a-f. Bull Acetabula

a: Medieval archaeological example, Ripon

b: Hawick Aurochs

c: Aiskew Juglans Nigra

d: Dalmuir Cyclone

e: Chillingham bull 1947

f: Chillingham bull c. 1980

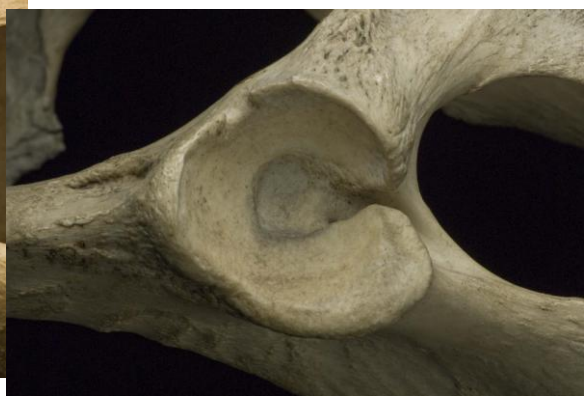


Plate 3: 1 Detail of Bestiary image of red heifer being milked with calf in attendance
(after Barber1999, Bodleian Library Oxford, MS Bodley 764)

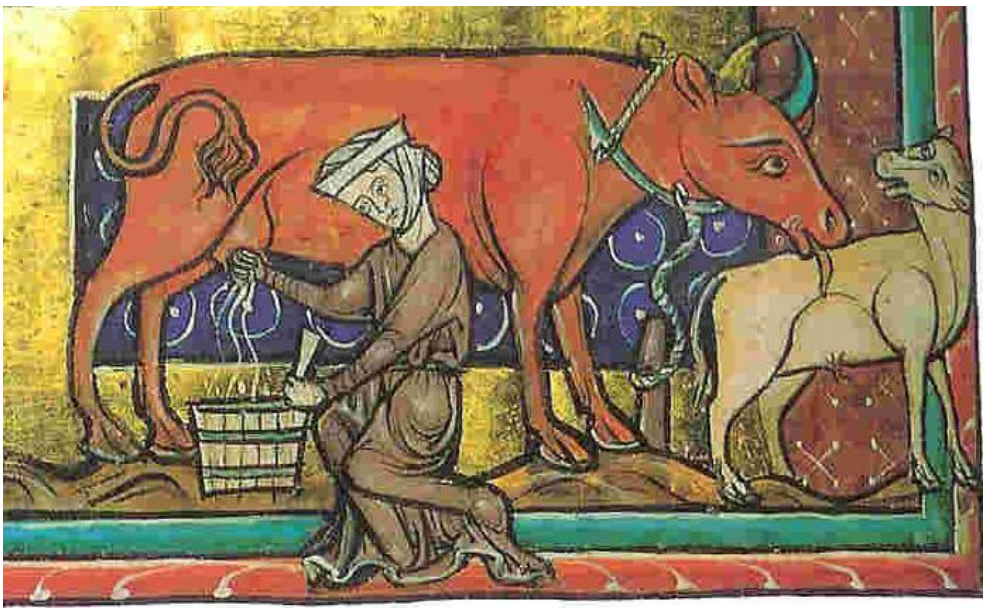


Plate 3: 2 Detail of Bestiary image of gambolling calves
(after Barber1999, Bodleian Library Oxford, MS Bodley 764)

Plates 3: 3a-e Dun calves showing winter coats with long guard hairs and woolly undercoat

Plate 3:3a Pyrite

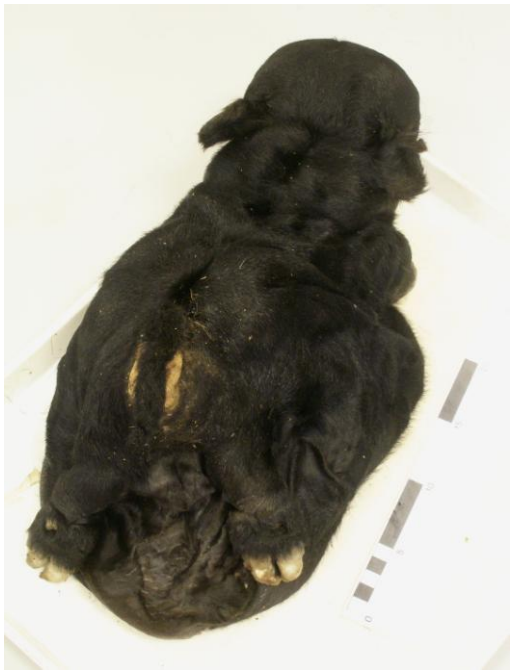
Plate Calf 3:3b
Pyrite: Detail of coat showing long guard hairs and short, woolly undercoat

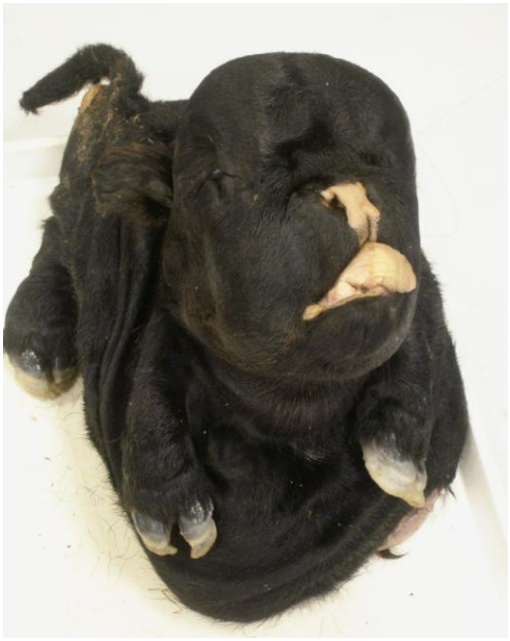
Plate Calf 3:3c
Detail of Pyrite's coat

Plate Calf 3:3d
Detail of Rebekanda's coat

Plate Calf 3:3e
Olivine displaying the same double coat

Plate 3: 4a-d. Four views of bulldog calf born in the Zanfara herd, dam Norscroft Cassie (in reference collection, Chapter 5)

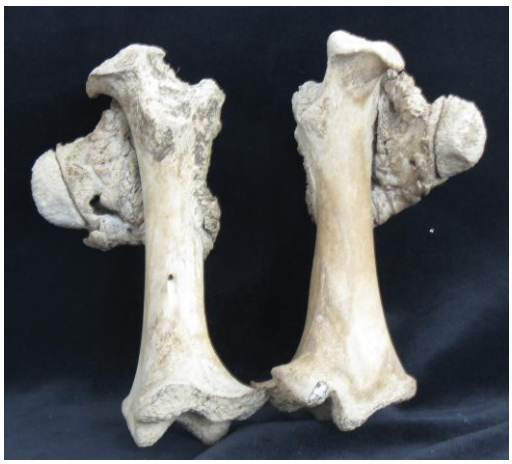




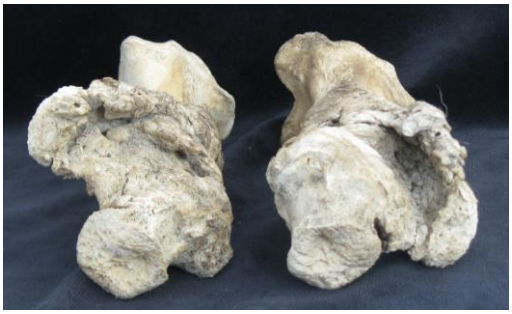
Plates 3: 5a-e Dozey: Pathological changes to femora, calcanea and acetabulae

3: 5a anterior view of femora showing displaced capitula

3: 5b posterior view of femora showing displaced capitula



3: 5c proximal view of femora



3: 5d calcanea

3: 5e Pubes, ischia, caudal half of acetabula

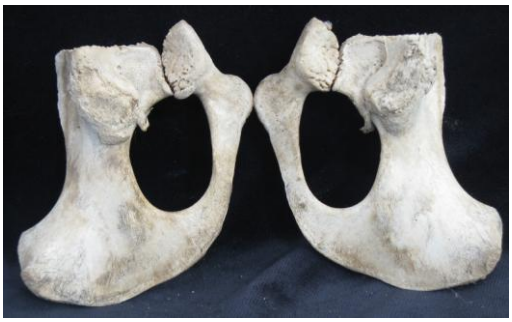


Plate 3: 6 Radii of Jersey, Edward, foreground and short-leg Dexter, Medlar, behind

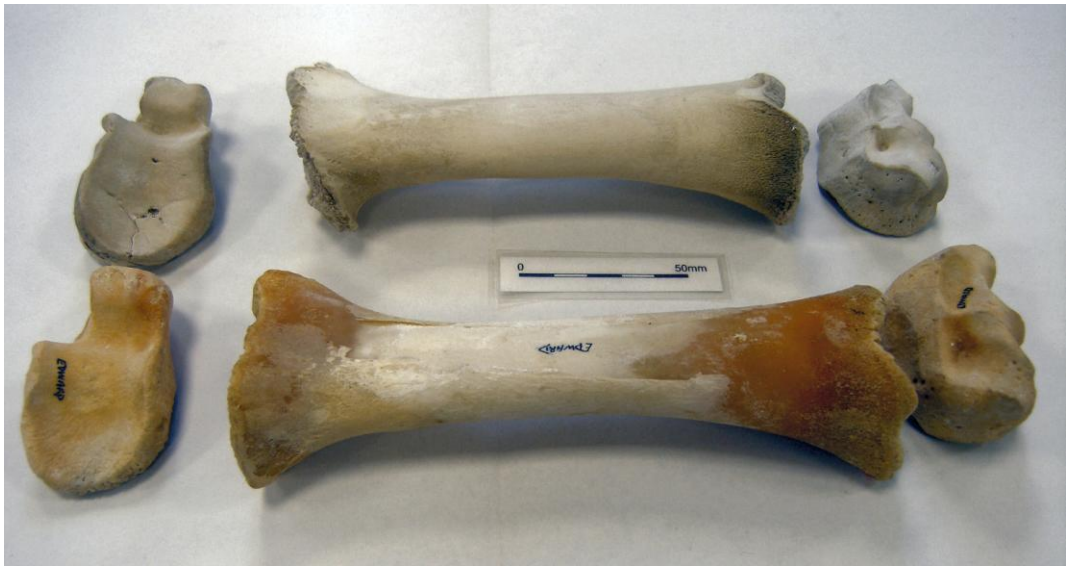


Plate 3: 7a Apicius cervical-thoracic vertebrae, lateral view

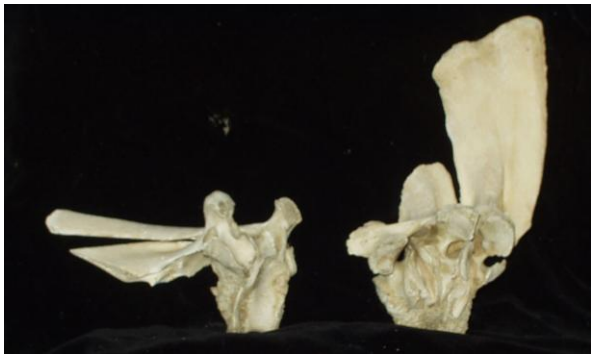


Plate 3: 7b Apicius cervical-thoracic vertebrae, medial view

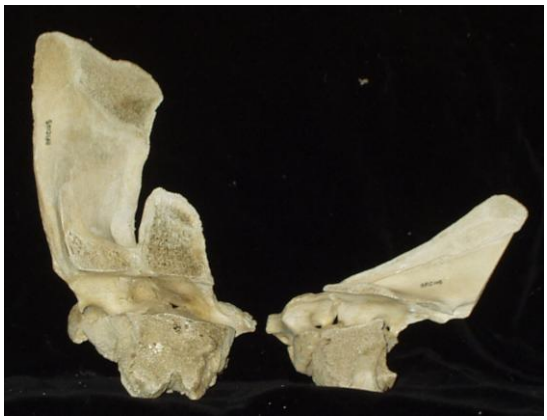


Plate 3: 8a Apicius sacrum, cranial view

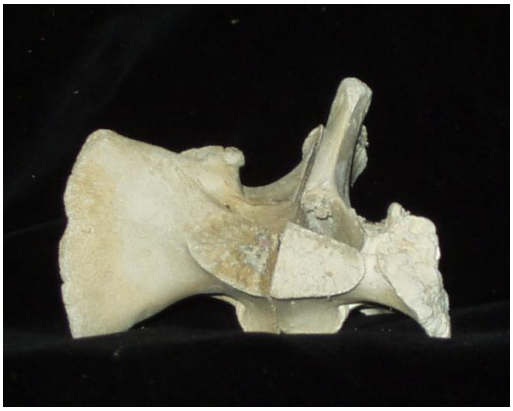


Plate 3: 8b Apicius sacrum, dorsal view

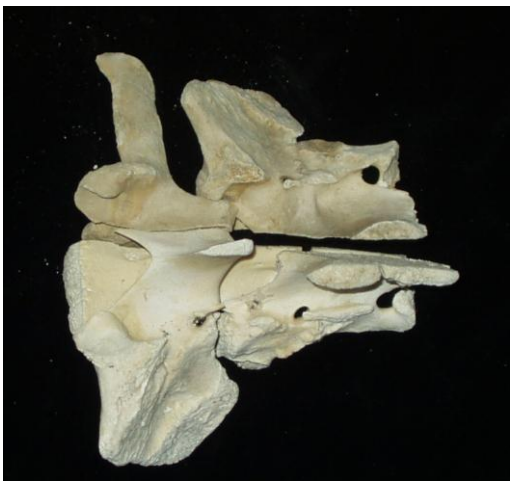


Plate 3: 9 L-R Nantwich, Dexter and commercial calf humeri

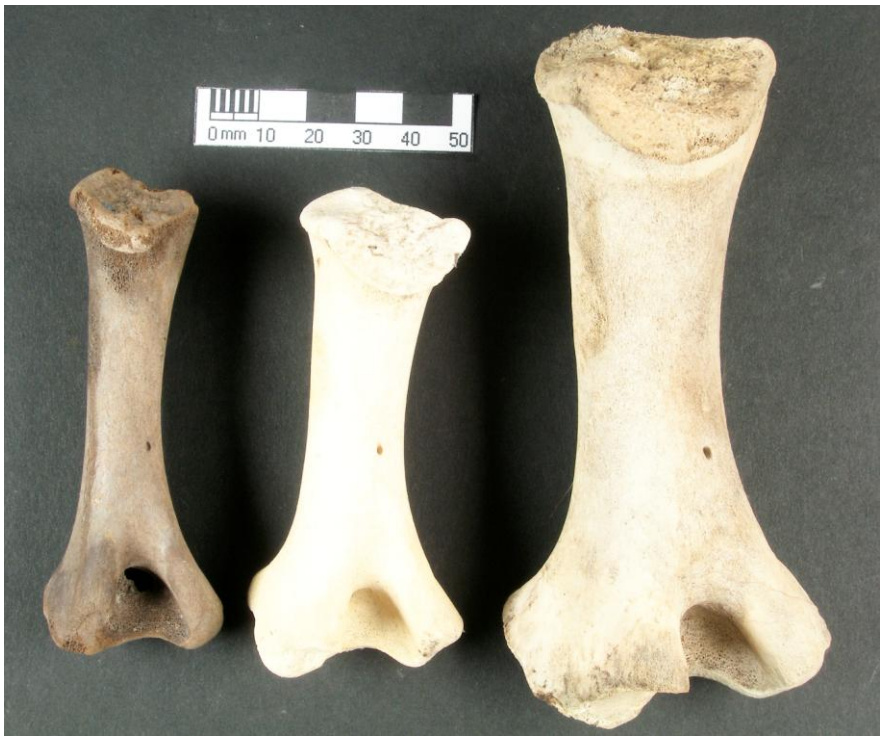
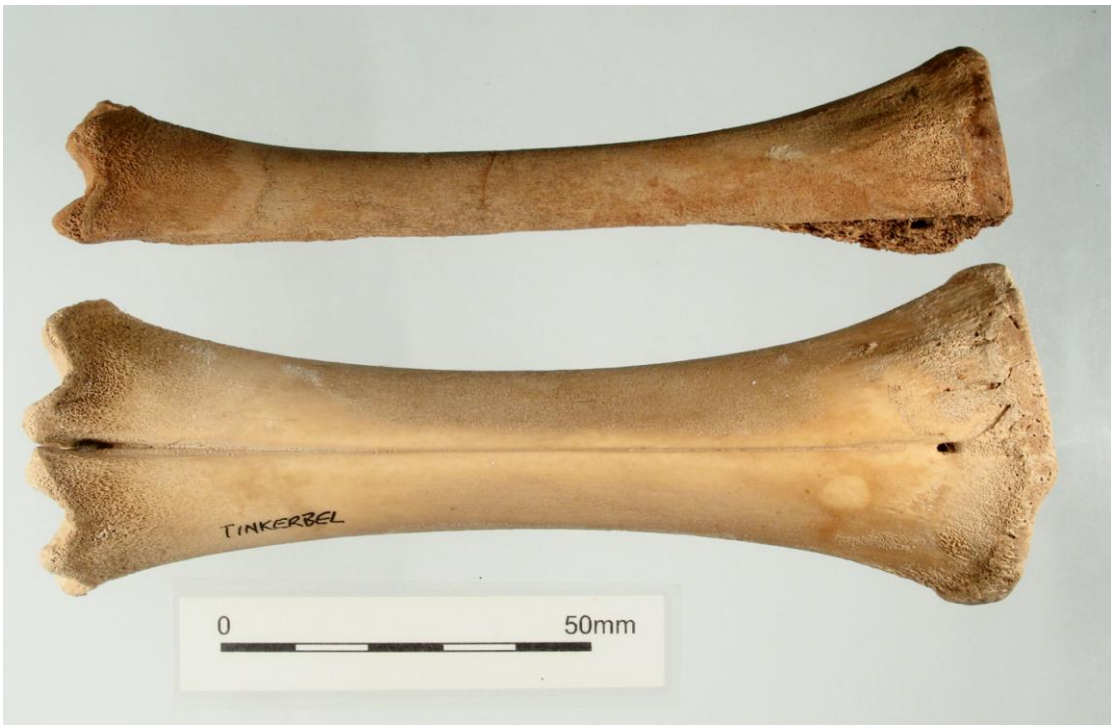


Plate 3: 10. Monkseaton Chapel Lane, cow skeleton with calf bones in abdominal region

Plate 3: 11. Metacarpals, top Durham, bottom Tinkerbel



Plates 3: 12a-c. Durham 18th century (brown) and new-born Dexter (white) calf frontal bones

Plate 3: 13a Aurelian, bull, showing pronounced horn buds. Born 11th January, photographed 9th March

Plate 3: 13b Tittlemouse, heifer, horn buds still concealed by hair. Born 21st January, photographed 9th March

Plate 3: 13c Aurelian left, Tittlemouse right. In a different pose, horn buds still visible on the bull calf but not the heifer.

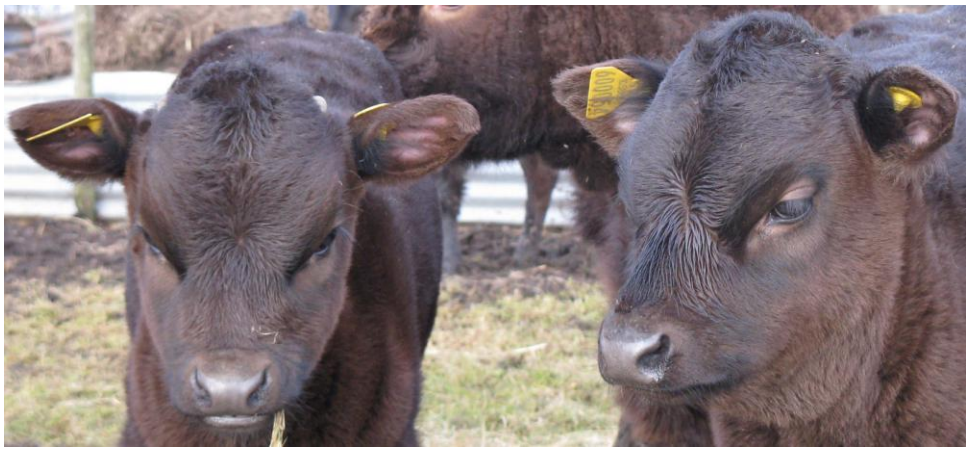
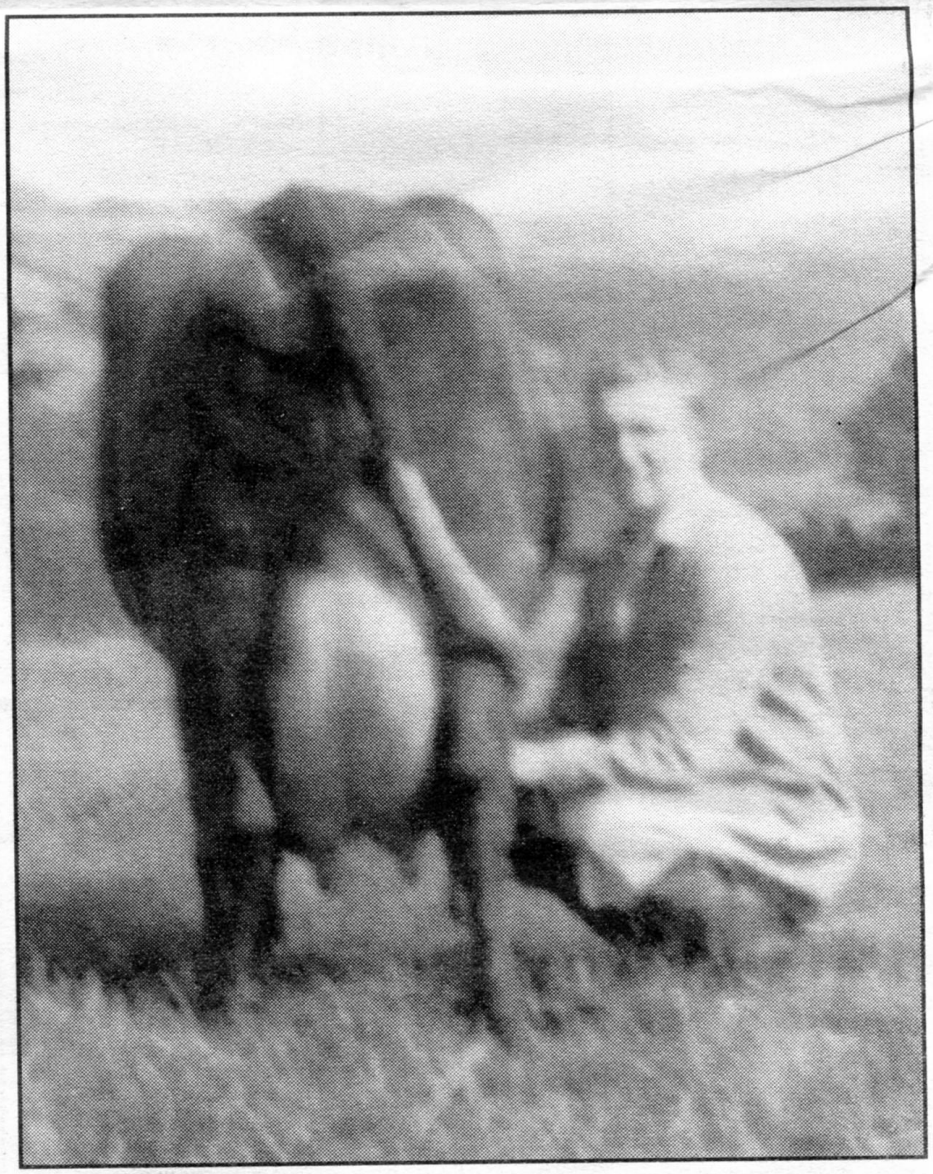


Plate 4: 1 Grinstead Trixie 8th, an example of a mid-20th century dairy conformation Dexter cow (world wide web image)

Plate 4: 2 Augsburg, Germany: early 16th century wall painting for the month of April, detail depicting a cow mounting another cow in oestrus (world wide web image)

Plate 4: 3 Shorthorn cow being handmilked while unrestrained, c. 1951-4
(Northern Farming Gazette)

ATTIC TREASURES



Photographed in 1951 with Ben Cherry is 'Burndale Nellie Keepsake'. She won the 'Oxton Cup' for being the highest yielding shorthorn in Yorkshire. It was given by Sam Smith's Brewery, Tadcaster. She was bought as a stirk at Penrith Sales about 1948 and brought down to Hand Bank Farm, Langsett. After producing 3 heifer calves she reacted, and I advised my boss at the time to buy her (£60). Around the time of this photograph (1954?) she was yielding well over 10 gallons daily (hand milking).

At Hand Bank Farm, Hugh Broadhead did the milking and was given a silver spoon. Burndale is the prefix of J Henderson & Sons, Burnt Tongues Farm, Allendale, Hexam. (Sent in by Ben Cherry).

Plate 4: 4 Early 16th century depiction of unrestrained cow, with no calf, being milked. Also note curved, upright “crumpled” horn shape (world wide web image)

Plate 4: 5a Modern breed with “crumpled horn”: Norwegian Vestlandsk Fjordfe (world wide web image)

Plate 4: 5b Modern breed with “crumpled horn”: Italian Cinisara
(world wide web image)

Plate 4: 5c Early 20th century Kerry cow with “crumpled horn”
(world wide web image)

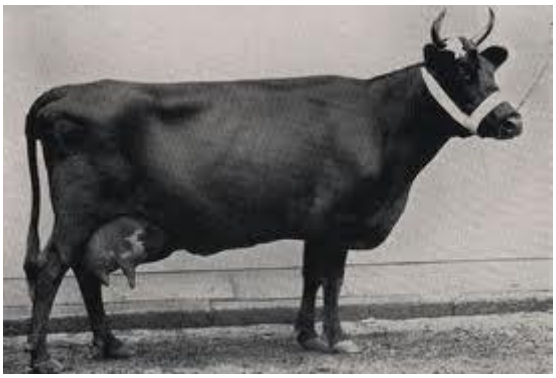


Plate 4: 6a The Dun Cow sculpture group on Durham Cathedral
(drawn by Norman Emery)

Plate 4: 6b 19th century sketch of the same Dun Cow sculpture group

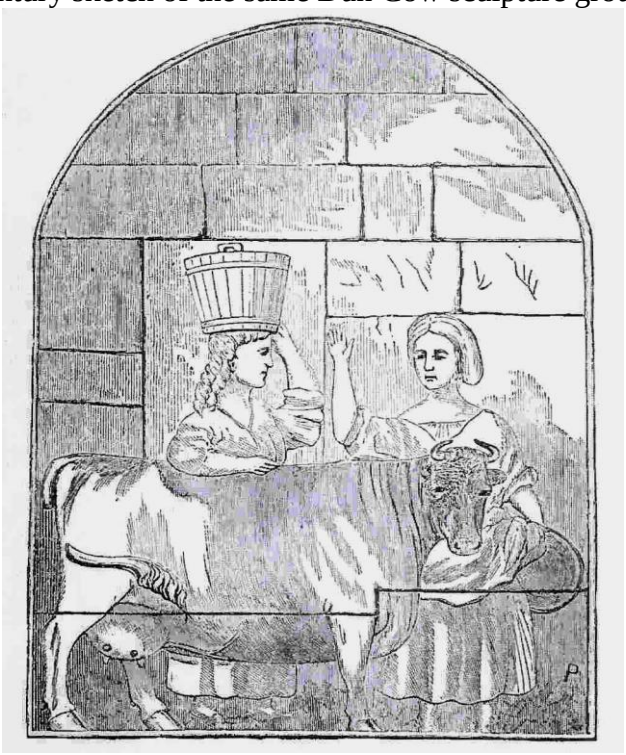


Plate 4: 7a Parndon Green Finch, aged 29 (photo Veronica Schofield)

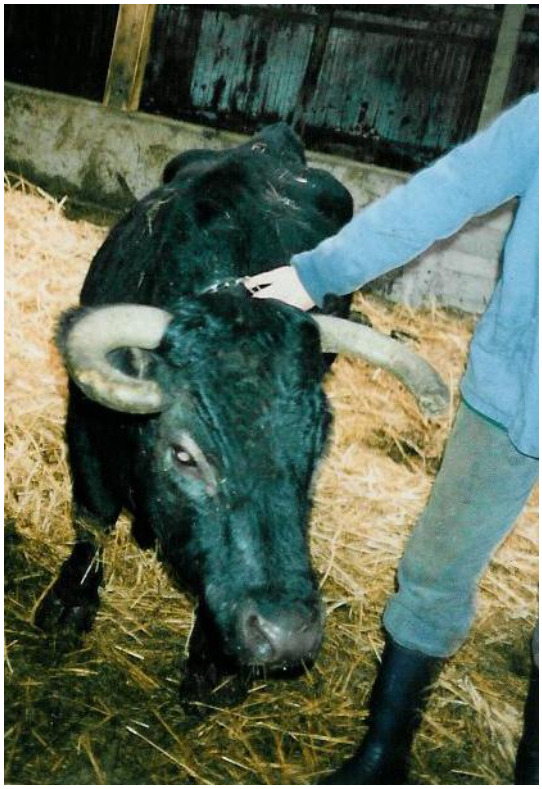
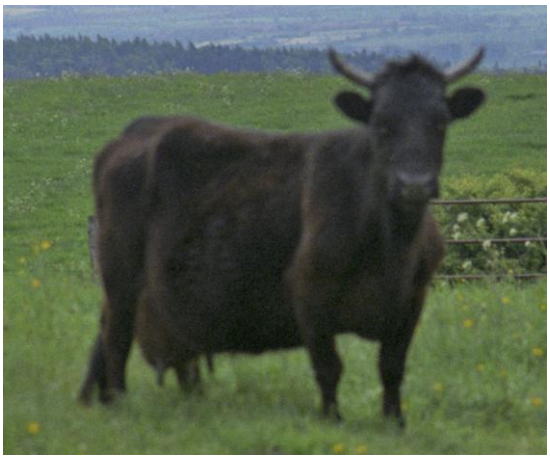


Plate 4:7 b Kirstie in life



4: 7c Kirstie in life

Plate 4: 8
Depression in horn core of Vycanny Kirstie

Plate 4: 9 Glenteitney caudal articulation VL6

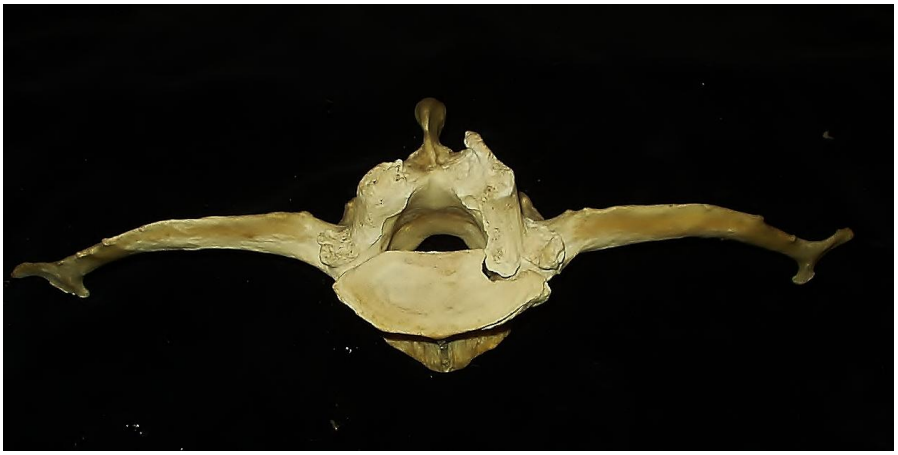


Plate 4: 10 Glenteitney cranial articulation sacrum

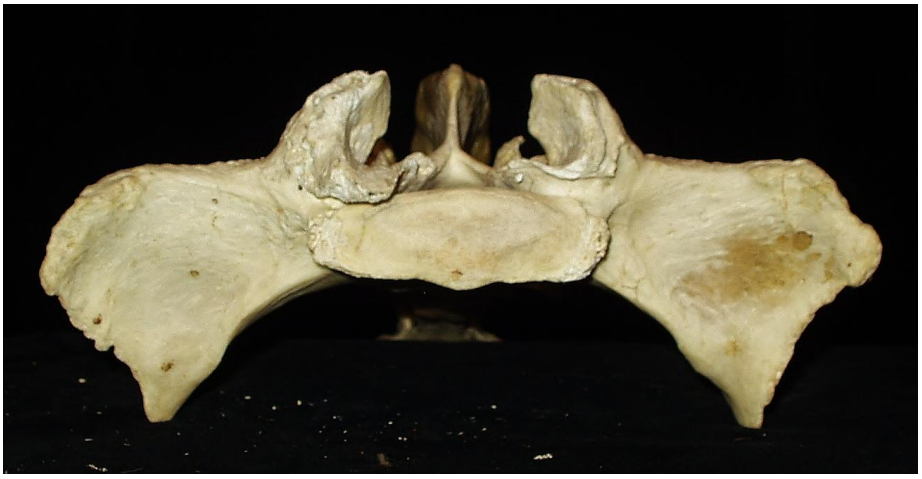


Plate 4: 11 Glenteitney lumbar and sacral vertebrae

Plate 4: 12 Glenfinlet Lumbar and sacral vertebrae

Plate 4: 13 Kirstie Lumbar and sacral vertebrae

Plate 4: 14 Keepsake Lumbar and sacral vertebrae

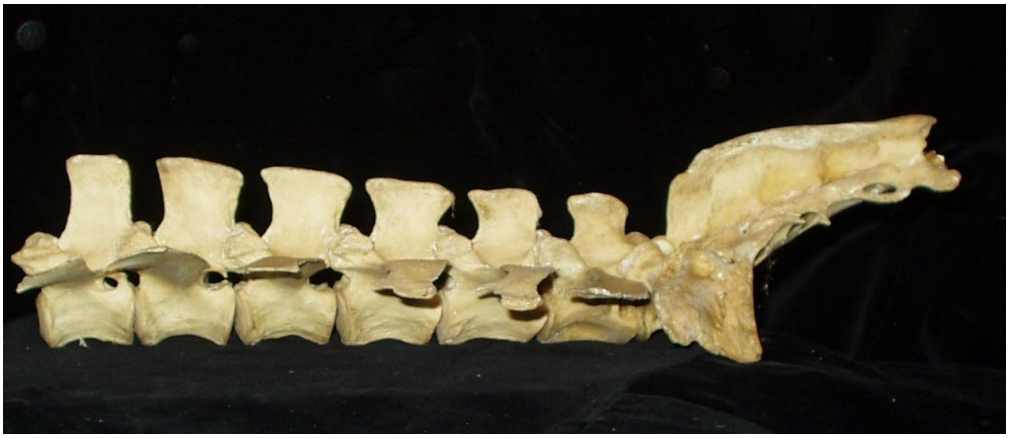


Plate 4: 15 Vycanny cow showing raised tail head at the lumbar-sacral boundary. Note also “dairy wedge” outline and the upright “crumpled” horns of the cow on the right.

Plate 4: 16 Vycanny Kirstie metatarsals, posterior view

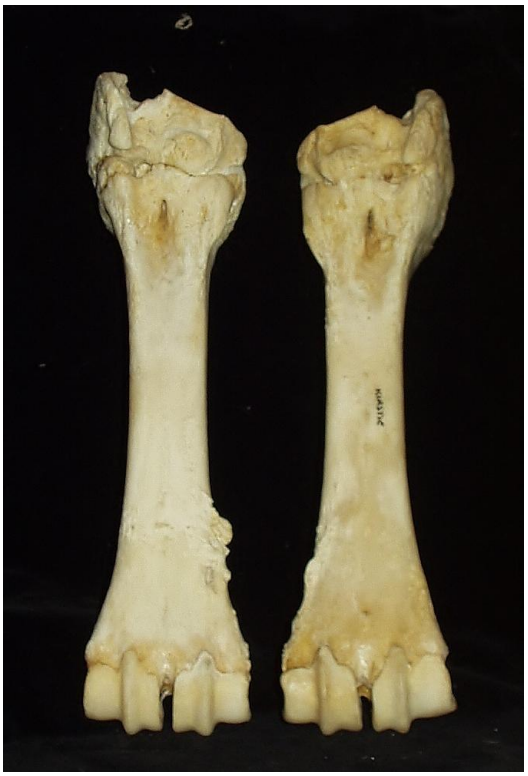


Plate 4: 17 Left distal metacarpal from medieval deposits at Tuthill Stairs, Newcastle upon Tyne; right metacarpal of Vycanny cow Glenfinlet

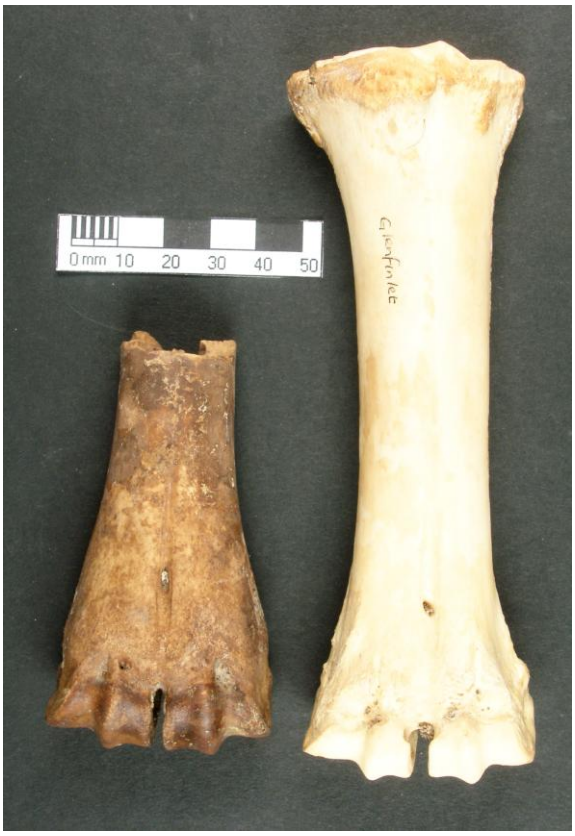


Plate 4: 18 Humeri: L & R Vycanny cows, centre Green Shiel

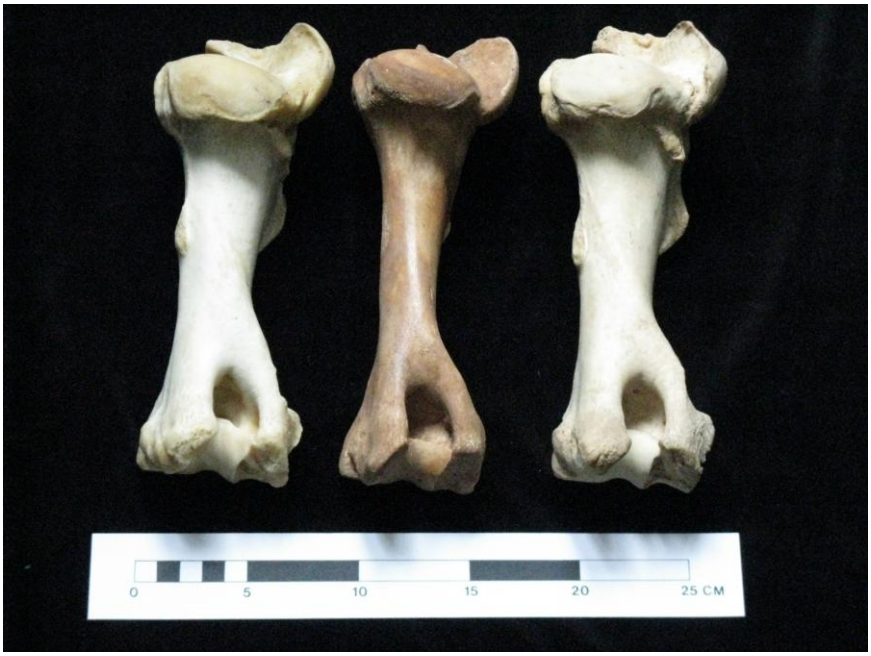


Plate 4: 19 Tibiae: L & R Vycanny cows, centre Green Shiel

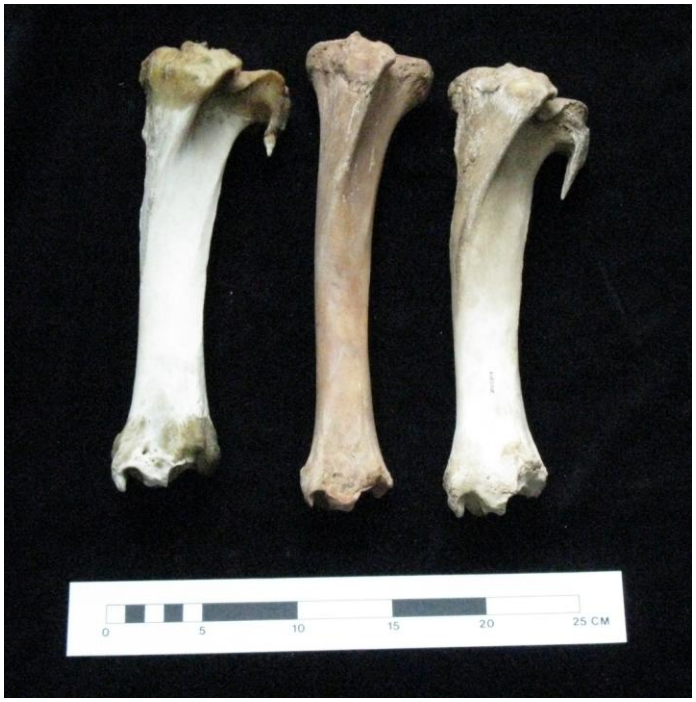


Plate 4: 20 L Green Shiel, R Chillingham bull

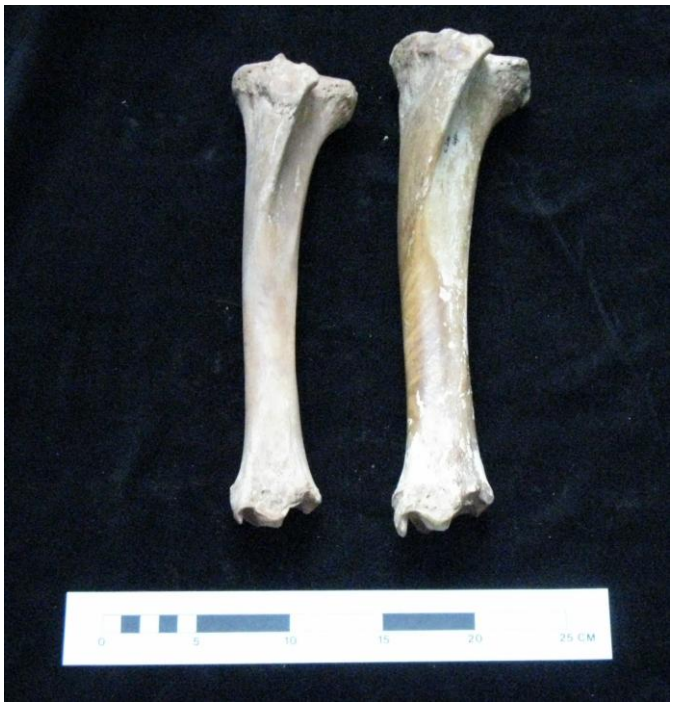


Plate 4: 21 Dexter cow in 2012, showing beef conformation
(photo Mark Bowles)

Plate 5: 1a. Laurelanda issuing a challenge

Plate 5: 1b. Tiggywinkle (left) establishing her rating as a newly-calved heifer

Plate 5: 1c continuing the same interaction

Plate 5: 1d Pyrite, right, attempting to dominate Tiggywinkle

Plates 5: 2a-c Naturally mummified head of Bryn Y Pin Betula

5: 2a frontal aspect

5: 2b lateral view

5: 2c showing separation of vertebrae

Plate 5: 3a Godstone Abby, 1989

Plate 5: 3b Abby with Chalena's calf

Plate 5: 4 Chalena after calving, 1989

Plates 5: 5a Cassie when newly calved in 1992

5: 5b Cassie when newly calved

Plate 5: 6 Meadow Pipit in 1988 (photo J & P Garratt)

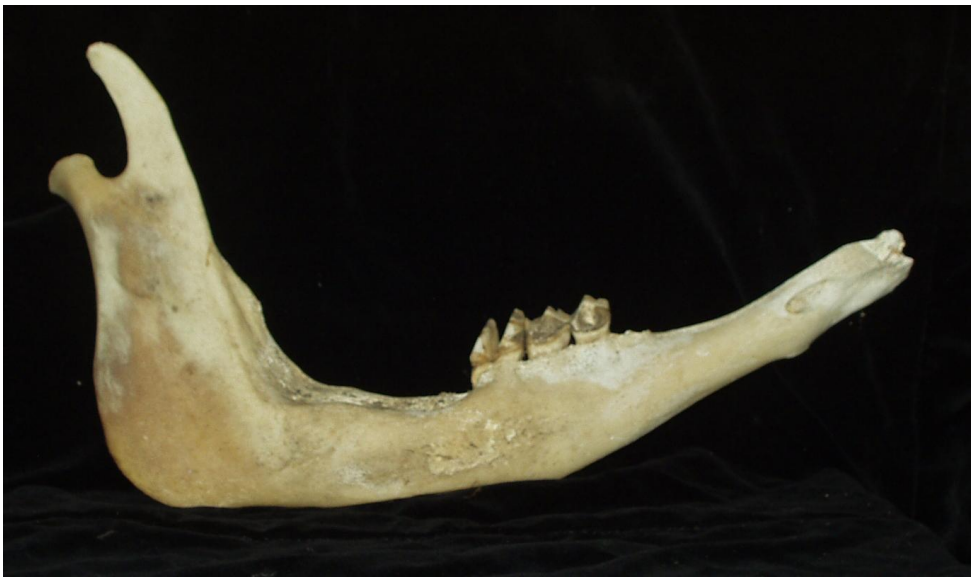
Plate 5: 7 Chevette in 1993 (photo J & P Garratt)

Plate 5: 8 Clover at Ryedale Show 1983 (photo J & P Garratt)

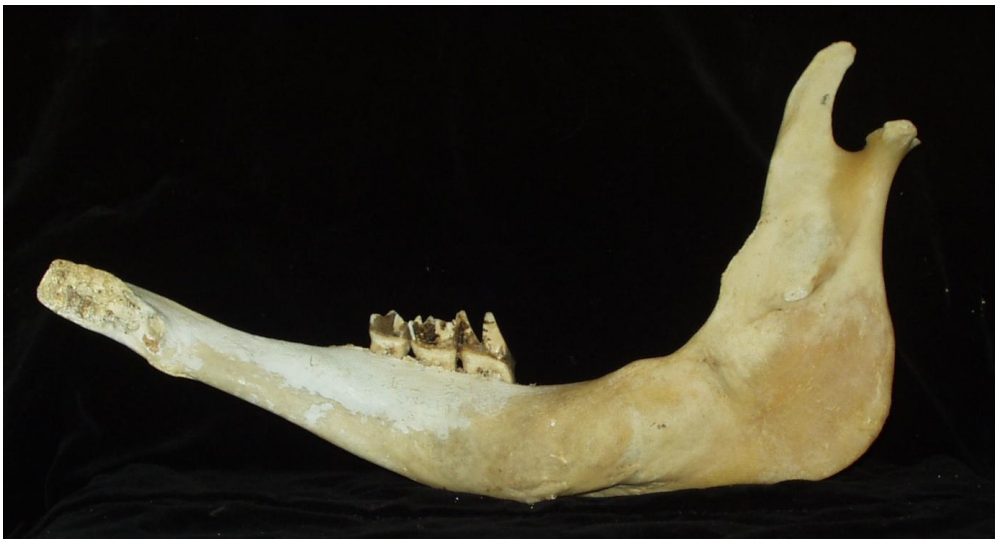
Plate 5: 9 Glenalmond 1983 (photo J & P Garratt)

Plate 5: 10 a-c Abby, right mandible showing healed trauma

5: 10a lateral view



5: 10b medial view



5: 10c ventral view

Plate 5: 11 Cassie, showing perforation in occipital

Plate 5: 12 Chevette, showing perforation above left occipital process

Plate 5: 13a Glenalmond, ribs showing healed fractures

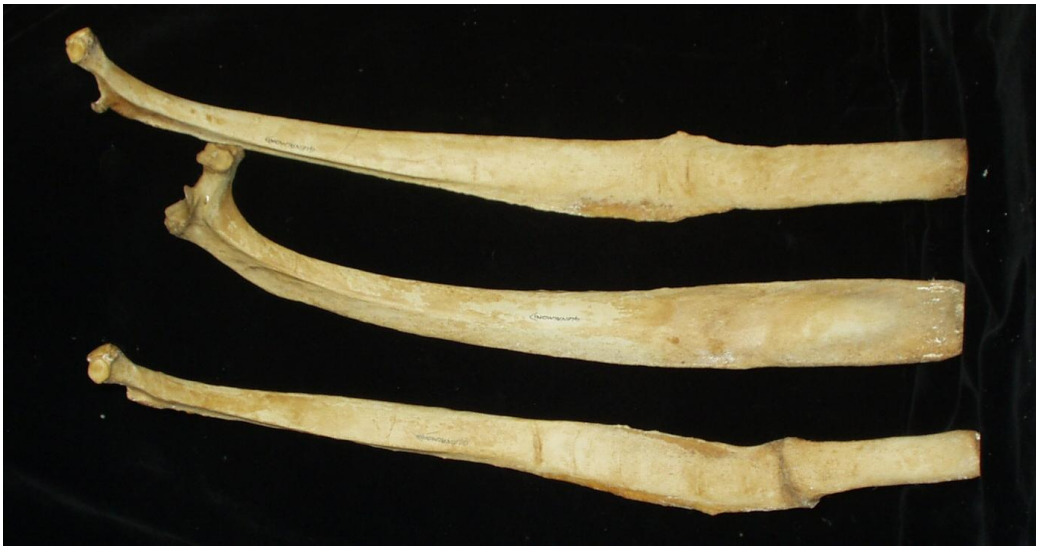


Plate 5: 13b Glenalmond, ribs showing healed fractures

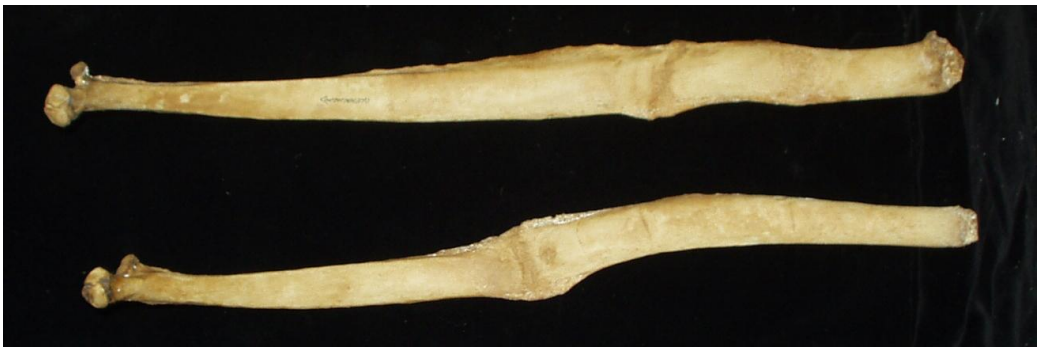


Plate 5: 14 Meadow Pipit, foramina on centra of thoracic vertebrae

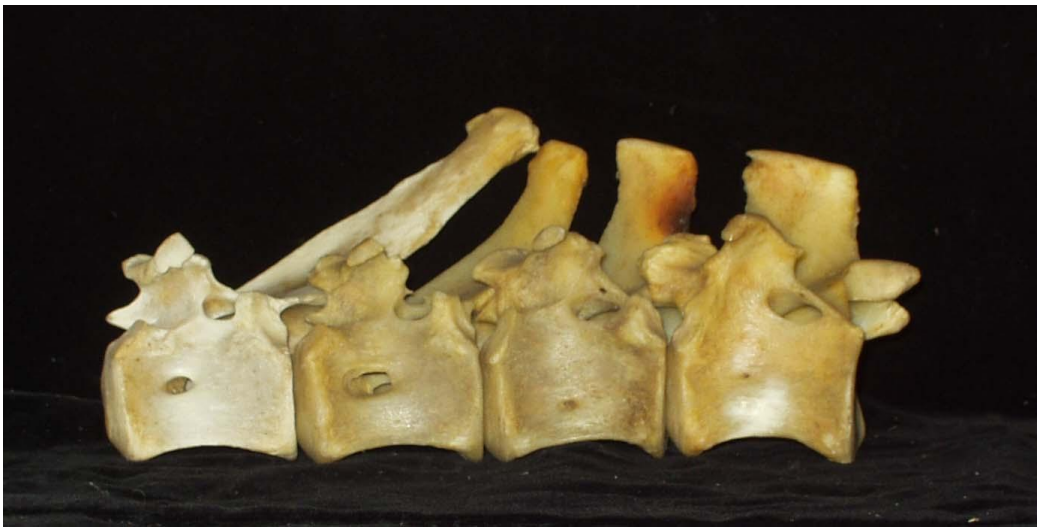


Plate 5: 15a Cassie, foramina on centra of thoracic vertebrae

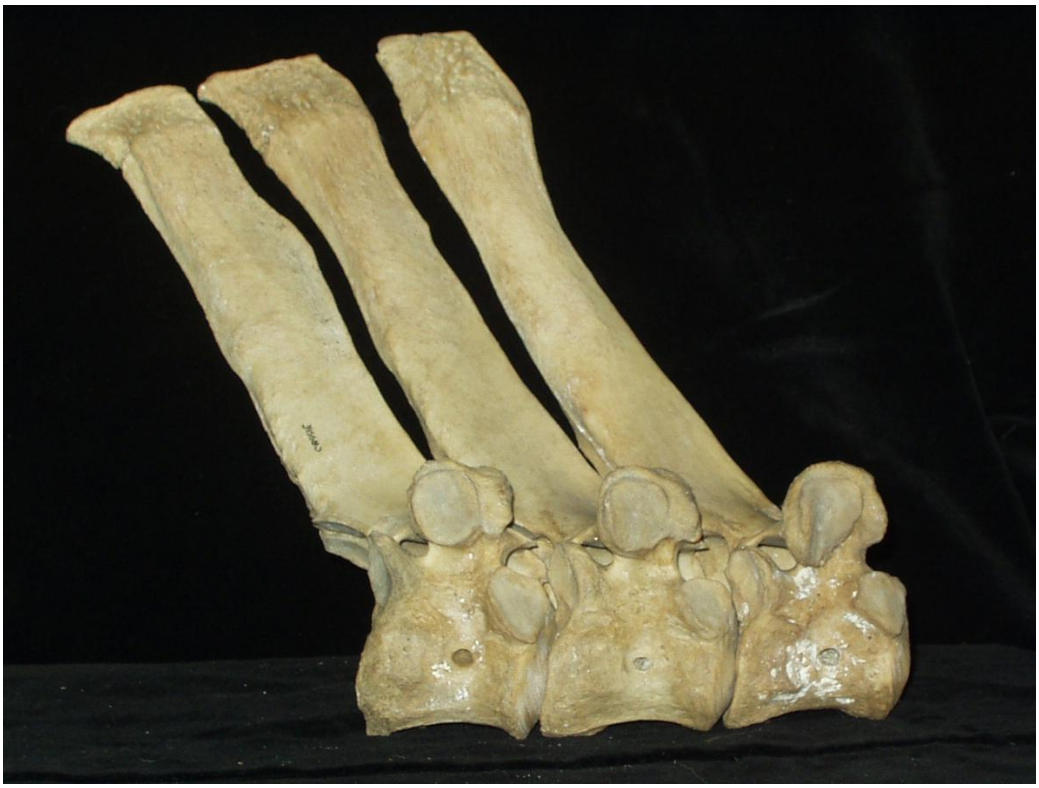


Plate 5: 15b-c Cassie, foramina on centra of lumbar vertebrae

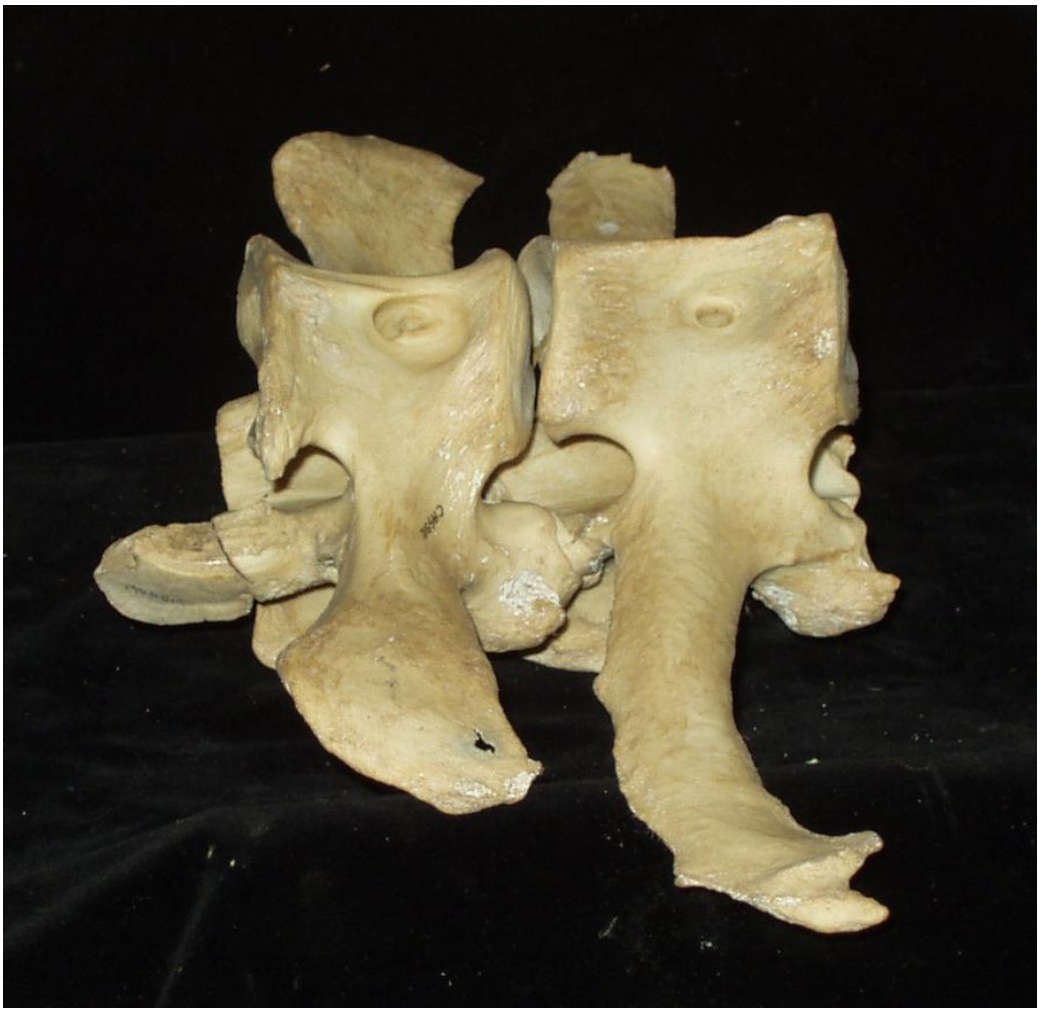
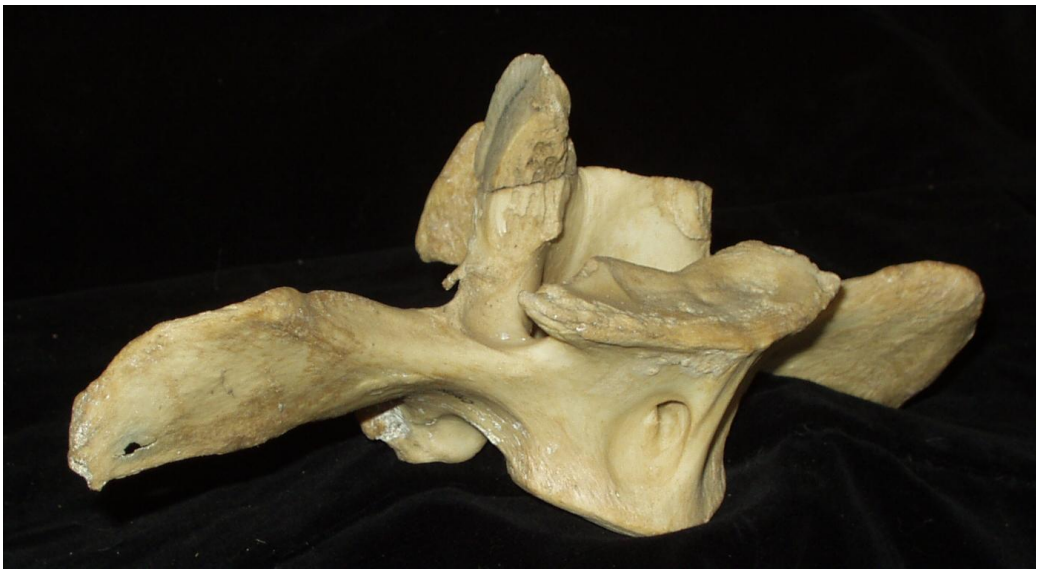
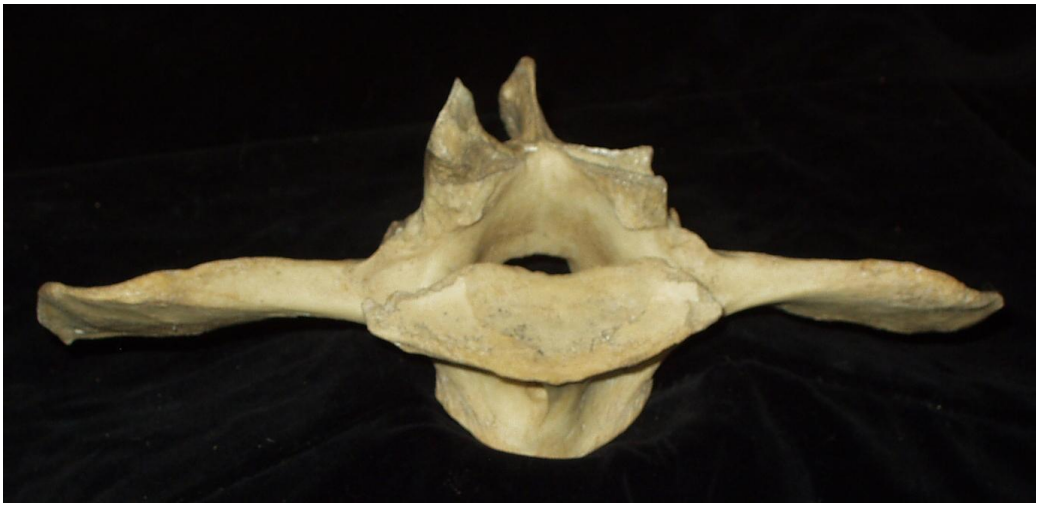


Plate 5: 15c Cassie, foramen on centrum of lumbar vertebra



Plates 5:15d-e Cassie, arthropathies on lumbar-sacral joint

5: 15d caudal aspect of VL6



5: 15e cranial aspect of sacrum

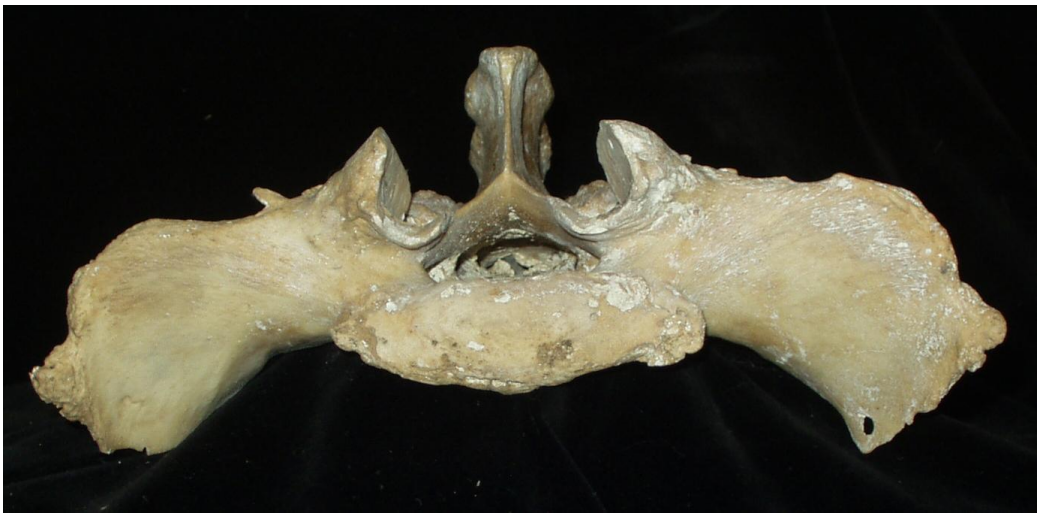
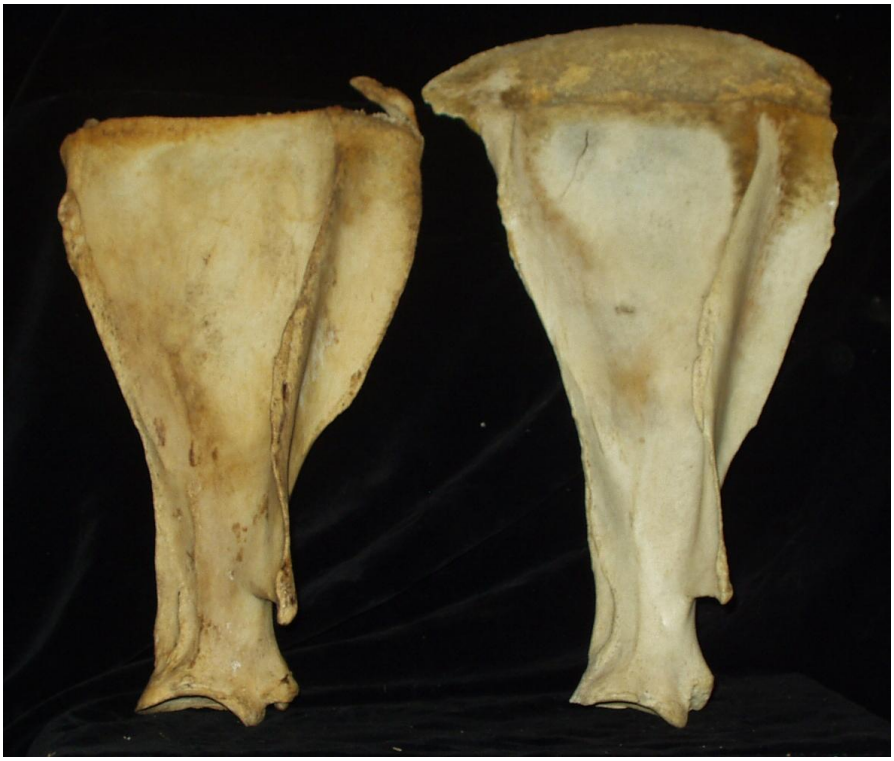


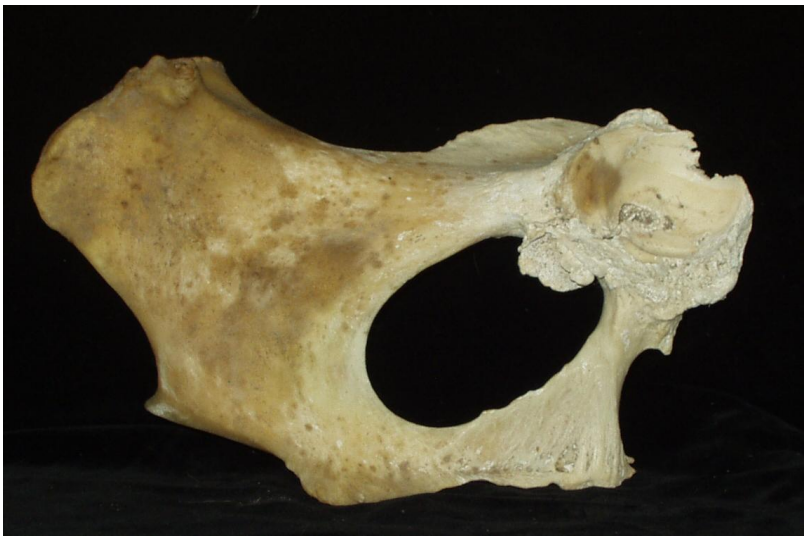
Plate 5: 16a-b Chalena and Meadow Pipit, scapulae

5: 16a lateral aspect



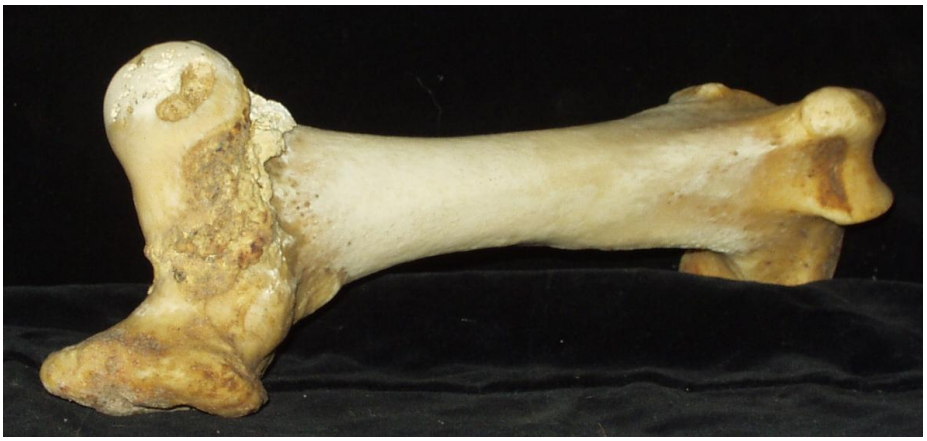
5: 16b medial aspect

Plate 5: 17a Clover, arthropathy on acetabulum



Plates 5: 17b-c Clover, arthropathy on articulating femoral head

5: 17b anterior aspect



5: 17c detail of femoral head

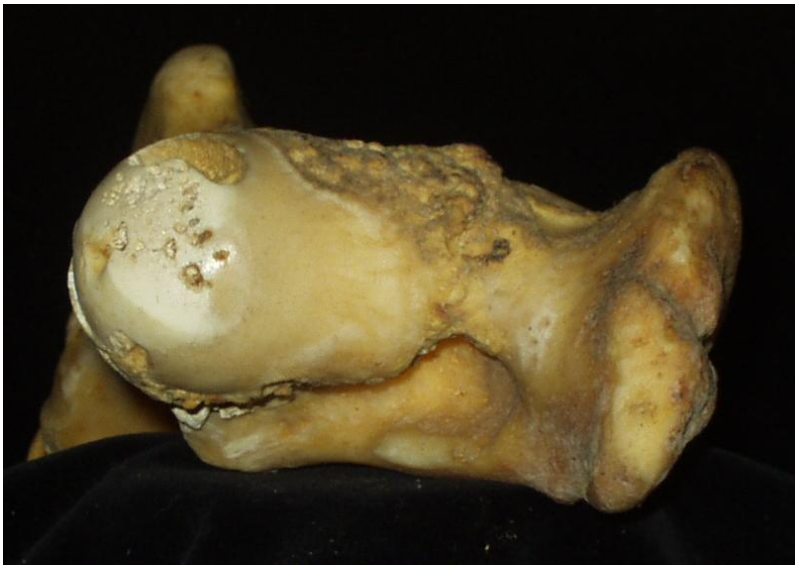


Plate 6: 1. Pack and riding oxen in the Sudan, 1934. (DUL SAD 705/4/5)

Plate 6: 2a Dexter cattle being used to tread cob for walling (Photo Alison Bunning)

Plate 6: 2b Detail of Dexter cattle treading cob (Photo Alison Bunning)

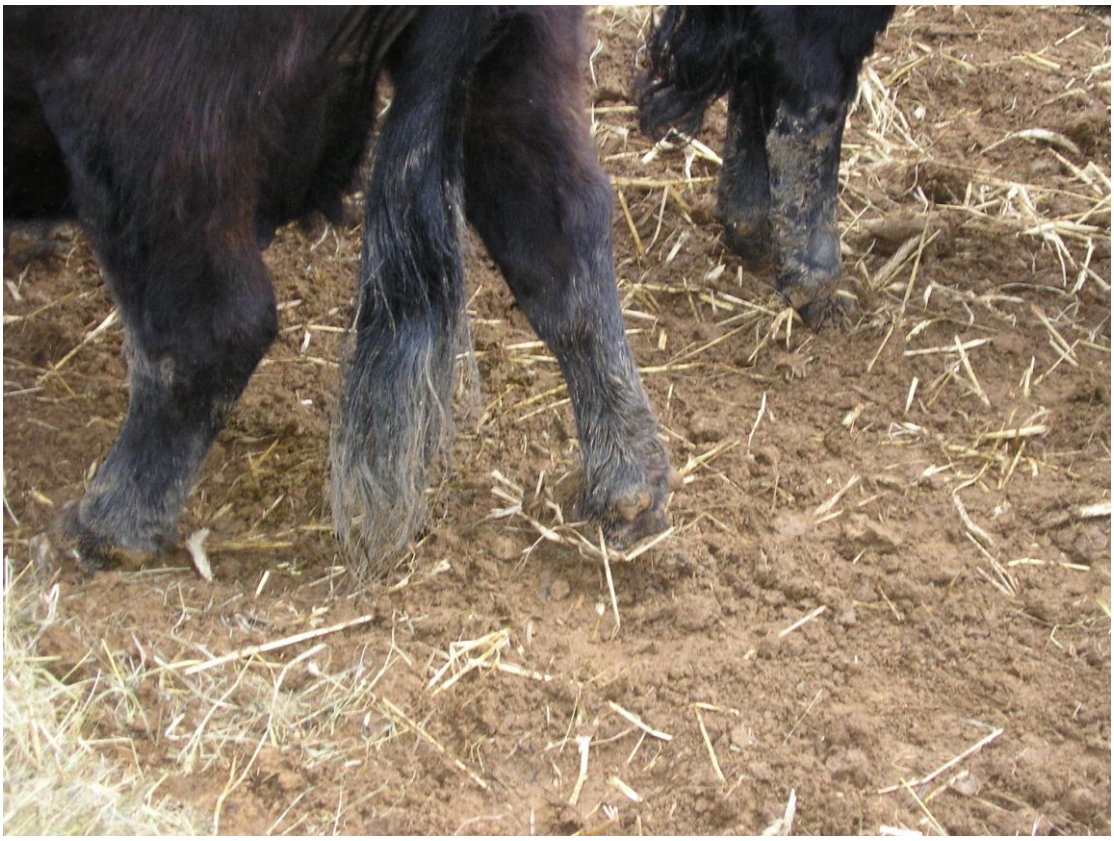


Plate 6: 3 Bantu and Wellington in training yoke, ploughing at Bede's World (Photo Peter Rowley-Conwy)

Plate 6: 4 One of the Dexter oxen as a weaned stirk

Plate 6: 5 Bantu at 11 years old with a related female, demonstrating the range of phenotype within one genotype

Plate 6: 6a Bantu and Wellington in withers yoke

Plate 6: 6b Bantu and Wellington in withers yoke, being led by the author

Plate 6: 7 Dexter heifers Jaquinta, left, and Clarissa, right, in training yoke

Plates 6: 8 a-c Oswald and Oswin at Bede's World, aged 11-12 years
(photos Bede's World)

Plate 6: 8a

Plate 6: 8b

Plate 6: 8c

Plate 6: 9a The 2013 Darlington roast ox standing in its frame, after removal from the oven, with the Master Butcher in attendance

Plate 6: 9b Serving the 2013 Darlington Roast Ox, calor gas-fired oven on trailer in background

Plate 6: 10 Exhibition Shorthorn Ox with Dexter heifer, souvenir postcard from 1950's agricultural show in Weardale

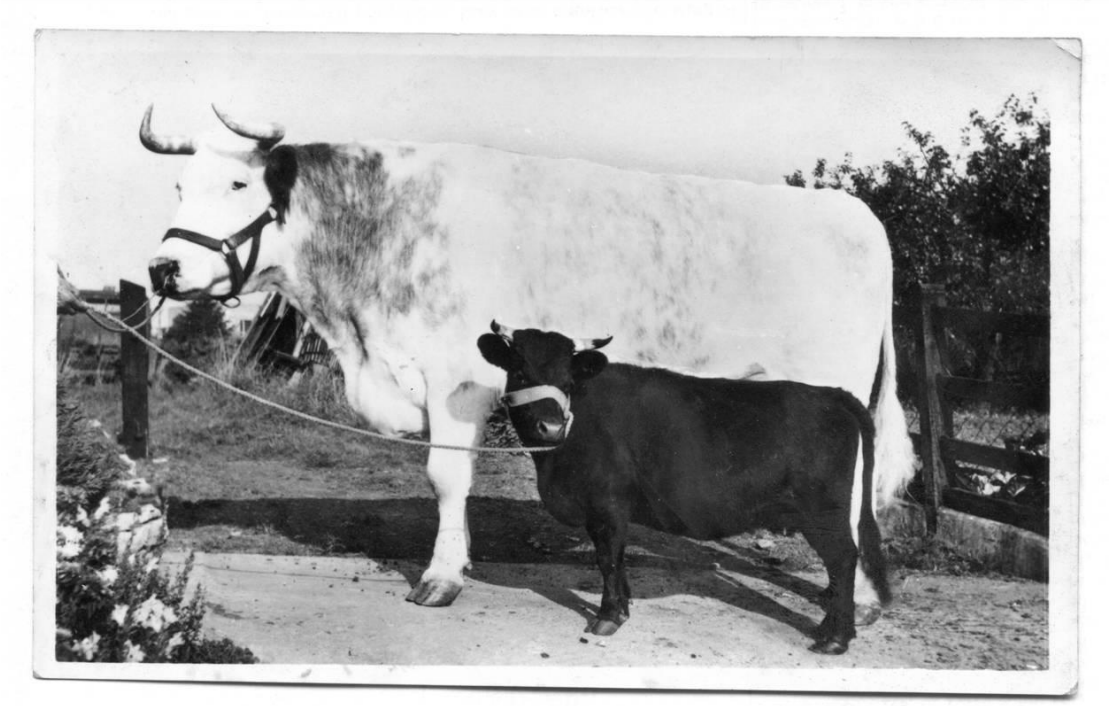


Plate 6: 11 Hadza, left, and Juglans Nigra, centre, in life

Plate 6: 12 Relative shoulder heights of Bantu, rear, the author, centre, and Clarissa, foreground

Plate 6: 13 Bantu, right, and Clarissa, left, comparing absolute size difference of heads with comparable horn morphology

Plate 6: 14a The Shapwick burial pit during excavation (Photo Chris Gerrard)

Plate 6: 14b The Shapwick burial pit during excavation, detail (Photo Chris Gerrard)